PERCEPTION OF FISHING COMMUNITIES ON CLIMATE CHANGE, FISH CATCH FLUCTUATIONS AND COPING STRATEGIES: KARONGA DISTRICT, MALAWI

MSc THESIS (FISHERIES AND AQUATIC SCIENCES)

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APRIL, 2025

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MASTER OF SCIENCE DEGREE IN FISHERIES AND AQUATIC SCIENCES

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A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF FISHERIES AND AQUATIC SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE (MSc) IN FISHERIES AND AQUATIC SCIENCES

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DECLARATION

I hereby declare that this thesis, titled " Perception of Fishing Communities on Climate Change, Fish Catch Fluctuations and Coping Strategies: Karonga District, Malawi," is my original work and a record of my research. All citations, references, and borrowed ideas have been duly acknowledged. This thesis is submitted in partial fulfilment of the requirements for the award of a Master of Science degree in Fisheries and Aquatic Science at Mzuzu University. None of this work has been previously submitted for any degree or examination at any other university, and no parts of this thesis have been submitted for publication or published.

_____ _____

Tikhala H. Chakalamba Date

CERTIFICATE OF COMPLETION

We, the supervisors, certify that this thesis is the result of the author's original work and, to the best of our knowledge, has not been submitted for any other academic qualification at Mzuzu University or elsewhere. The thesis is acceptable in form and content, and the candidate demonstrated satisfactory knowledge of the field through an oral examination held on ...../……/……

Major Supervisor: Prof. Fanuel Kapute

Signed: …….

Date: …….

Co-Supervisor: Dr. Kumbukani Mzengereza

Signed: …….

Date: …….

DEDICATION

This thesis is dedicated to my loving parents, whose sacrifices, encouragement, and unconditional love have been the foundation of my success. To my dear siblings, your prayers and love have been invaluable, and I am deeply thankful for the strong family bond that has inspired and uplifted me. This achievement would not have been possible without you all.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADC	Area Development Committee
AEPA	Australian Environmental Protection Authority
BVC	Beach Village Committee
CMIP5	Coupled Model Intercomparison Project 5 model
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GoM	Government of Malawi
IFRC	International Federation of Red Cross
IPCC	Intergovernmental Panel on Climate Change
MOEFCC	Ministry of Environmental Forest and Climate Change
MRCS	Malawi Red Cross Society
NAPA	National Adaptation Programme of Action
NORHED	Norwegian Programme for capacity development in higher education and research for development
NCCMP	National Climate Change Management Policy
NSO	National Statistical Office
SDG	Sustainable Development Goal
SPSS	Statistical Package for the Social Sciences
VCPC	Village Civil Protection Committee
VDC	Village Development Committee

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ABSTRACT

Perception of climate change is crucial in shaping communities' responses to climate risks and adaptation strategies. Therefore, this study examined fishing communities' perception of climate change, fish catch fluctuations, and coping strategies in Karonga District. Primary data was collected from fishers, local conservation groups, and village management structures using a household survey, focus group discussion, and key informant interviews. A total of 311 fisher households were purposively sampled. Secondary data on meteorological variables and fish catches over the past three decades were analyzed to validate fishers' perceptions. Data analysis, including binary logit model and Pearson correlation, was conducted using SPSS version 26, with descriptive statistics in Excel 2019. Results showed that 97% of fishers were aware of climate change, and 90% had experienced extreme climate events. Time series data aligned with perceptions of rising temperatures but contradicted perceptions of decreased rainfall. Respondents (95%) acknowledged that climate change impacted fisheries production, reporting the scarcity of historically abundant species such as *Copadichromis spp.*, *Opsaridium microlepis*, and *Oreochromis karongae*. There was a negative relationship between temperature and fish catch ($r = -0.34$, $p < 0.005$, $n = 68$) and a positive relationship between rainfall and catch ($r = 0.33$, $p < 0.006$, $n = 68$). Fishers (88%) reported a decrease in fish catch and 96.5% had coping mechanisms, including income diversification, longer fishing hours, and modified gear. Access to extension workers increased the probability of fishers' adaptability. However, unsustainable coping mechanisms, such as closed-season fishing and illegal gear usage, highlight the need for more training on climate risks and sustainable adaptation. These findings provide local knowledge for policy formulation to enhance adaptive capacity and support sustainable livelihoods in Malawi.

Key words: *Climate change, coping strategies, fisheries, sustainable adaptation, Lake Malawi*

CHAPTER ONE: INTRODUCTION

1.1 Introduction and Background of the Study

Perception of climate change in rural areas is shaped by social and cultural processes, which influence people's beliefs and knowledge differently from scientific researchers (Slovic *et al.*, 1987; Deressa *et al.*, 2011). This perception plays a crucial role in how communities respond to climate-induced risks and opportunities, directly impacting their adaptation strategies (Adger *et al.*, 2009; Pauw, 2013). Misunderstanding of climate change can lead to inadequate adaptation or no adaptation, worsening its negative effects (Grothmann and Patt, 2005). Therefore, community resilience requires knowing and improving the community's adaptive capability to respond to climate-related changes in natural resources like fish catch (Seara *et al.*, 2016). Climate change is a significant challenge in developing countries, where vulnerability is heightened due to heavy reliance on natural resources and limited adaptive capacity (Goulden, 2006; Maddison, 2007). According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to long-term changes in climate patterns, spanning decades or longer (IPCC, 2018). Climate change risks, while uncertain, are real and expected to accelerate during the 21st century at unprecedented rates (Easterling *et al.*, 2007).

Malawi faces a variety of climate hazards that disproportionately affect rural populations, including floods, droughts, strong winds, and heatwaves, which contribute to malnutrition, poverty, and loss of life (GOM, 2010) Additionally, most Malawians (85%) live in rural areas and their households are susceptible to several shocks, such as climate change impacts, which increase their vulnerability to poverty (Pauw *et al.*, 2011; Mussa, 2013). The problem is exacerbated by Malawi's status as one of the poorest countries globally, with over 50% of the population living

below the poverty line and 25% living in extreme poverty (The World Bank, 2017). This has resulted in rural populations predominantly relying on agriculture, fisheries, and other climate-sensitive resources for their livelihoods, with fisheries being the mainstay due to the existence of open access conditions (Goulden, 2006). Lake Malawi's fisheries resource provides food, nutritional security, a source of income, subsistence and employment to the rural and urban poor communities. The fisheries sector is estimated to have contributed about 7.2% to the Gross Domestic Product in 2017 (Torell *et al.*, 2020). Small-scale fisheries provide a livelihood to more than 200,000 rural Malawians and more than 90% of Malawi's yearly fish catches come from small-scale fishers (GOM, 2016; Simmance *et al.*, 2021).

Fish is the most affordable source of animal protein for many rural Malawians however, dwindling fish catches have led to food insecurity and malnutrition for many rural communities that cannot afford alternative sources of animal protein (Tweddle and Lewis, 1990). This poses a severe threat to the economic (NSO, 2005), and social stability of the communities' dependent on fisheries (Banda *et al*., 2005). Malawi's fisheries resource is vulnerable to both climate change and human-induced pressures, such as overfishing, weak governance and illegal fishing practices (GoM, 2012). Climate-related factors such as changes in wind patterns, temperature, rainfall, as well as changes in lake water levels, disrupt fish reproduction, distribution, and growth, leading to lower fish catches (O'Reilly *et al.*, 2003; Mcsweeney *et al.*, 2010) thus affecting fishing communities' livelihood. The impacts of climate change on Malawi's fisheries, are a growing concern, with more frequent droughts and floods exacerbating the situation (Allison *et al.*, 2009). The effects of climate change are a subject of debate within the country and it is expected that the country will continue to experience significant variability and change in temperature and rainfall.

Fishers all over the world have developed several coping and adaptation mechanisms in response to low fish catches and climate change impacts through diversification of income sources (Limuwa *et al.*, 2018). Coping strategies are localized responses to stressors, both positive and negative, that help mitigate climate impacts but are often short-term and risk-spreading (Smit and Wandel, 2006). Some fishers adopt reactive and unsustainable measures like increasing fishing time, using illegal nets, and taking loans, which can lead to environmental degradation (Esia-Donkoh, 2017; Ilosvay *et al.*, 2022). In contrast, adaptation strategies are long-term, sustainable responses that enhance resilience, such as diversifying into farming, small businesses, and village banking (Gallopín, 2006; Muringai *et al.*, 2022). These strategies improve food security and stabilize incomes, reducing vulnerability to climate and economic shocks (Deb and Haque, 2016). The ability of fishers to cope with climate change is influenced by factors such as income, age, education, access to weather information and extension services, and participation in conservation efforts therefore, these factors should be considered when developing adaptation policies (McGrath *et al.*, 2007; Bryan *et al.*, 2013; Limuwa *et al.*, 2018).

Understanding how fishing communities perceive climate change, its effects on fisheries and fishers coping strategies to these consequences is crucial for the development of climate change management actions and adaptation policies (Muringai *et al.*, 2021). This can be achieved by enhancing local adaptive capacity, essential for fostering resilience to climate change and strengthening existing livelihood activities, such as crop and livestock farming, and small-scale businesses, which can improve food security and provide economic stability amidst climate variability (Limuwa *et al.*, 2018). Developing proactive measures to adapt to climate change

impacts will help rural communities survive climate change impacts and ensure sustainability of the fishing industry while reducing environmental pressure on fisheries.

1.2 Problem statement

Small-scale fishing communities in Malawi are increasingly vulnerable to the impacts of climate change and environmental degradation due to their heavy reliance on natural resources coupled with low adaptability levels. Along Lake Malawi, fishers rely on fishing as their primary livelihood, yet fish catches have declined over the past two decades, threatening both food security and income generation (Msiska *et al.*, 2017). Key commercial species such as *Oreochromis* species, *Rhamphochromis* species and *Labeo mesops*, are becoming increasingly scarce, due to climate change, overfishing, and weak fisheries governance (Allison *et al*., 2007; Limuwa *et al.*, 2018; Muringai *et al*., 2021). As fish stocks dwindle, fishers' income declines, worsening poverty and limiting access to alternative livelihoods. This issue is particularly severe in Karonga District, where extreme weather events and a lack of alternative occupations exacerbate economic insecurity (Pasquini, 2020). Despite the severity of the crisis, there is limited research on how small-scale fishers in the district perceive climate change, the extent to which they attribute declining fish catches to climate-related factors, and how they are adapting to these environmental challenges.

Several studies have explored climate change perceptions and adaptation strategies among fishing communities in various lakes in Malawi, including Lake Chilwa and Central Lake Malawi (Jørstad and Webersik, 2016; Nagoli and Chiwona-Karltun, 2017; Limuwa *et al.*, 2018). These studies highlight fisher’s awareness of climate change impacts on fisheries and livelihoods, as well as their

ability to pursue alternative income-generating activities in order to cope. However, these findings are region-specific and may not apply to all of Malawi's lakeshore communities due to varying local contexts. Thus, further studies are needed to inform localized policies that effectively support sustainable livelihoods and ecosystem management.

Climate projections indicate that climate variability in Malawi will continue to intensify, further impacting fishery resources and livelihoods. However, there is uncertainty regarding how and to what extent small-scale fishers are adapting to both the current overexploitation of fishery resources and the expected future changes in fish catches due to shifting environmental conditions (Boko *et al.*, 2007; Phiri and Saka, 2008; Zinyengere *et al.*, 2014; Stevens and Madani, 2016). Therefore, strengthening fishers' resilience requires a deeper understanding of their perceptions of climate change, the observed impacts on fish stocks, and the adaptation measures they employ (Behrenfeld *et al.*, 2006; Cheung *et al.*, 2009). This study aims to fill this knowledge gap by examining how small scale fishers in Karonga perceive and respond to climate-related changes in fishery resources.

1.3 Objectives of the study

1.3.1 Main Objective

To examine the perception of fishing communities on climate change, fish catch fluctuations and coping strategies in Karonga district.

1.3.2 Specific objectives

I. To examine fishing communities' perception of changes in major climate factors (rainfall, temperature, lake water level, wind) in Karonga district.

II. To examine the perceived climate change impacts on fish catches in Karonga district.

III. To assess the coping strategies of the fishing communities in Karonga district.

1.4 Research questions

The following questions provided the basis for the study:

I. What perceptions do fishing communities in Karonga have over climate change in the past 30 years?
II. What are the perceived climate change impacts on fish catches?
III. What are the coping strategies adopted by the fishing communities?

1.5 Significance of the Study

This study contributes to the existing body of knowledge on climate change adaptation mechanisms of fishing-dependent households amidst dwindling catches. Responding to climate change impacts requires a multi-level, interdisciplinary, integrated response and public participation. Therefore, understanding how fisherfolk perceive and respond to climate change is crucial for driving behavioral change and informing strategies to mitigate fishery decline. The findings also support Malawi's National Adaptation Programme of Action (NAPA), which aim to identify and promote activities that address urgent and immediate needs for adaptation of rural community's vulnerability to the adverse impacts of climate change and extreme weather events.

The study supports the National Climate Change Management Policy (NCCMP), whose long- and medium-term goals aim to reduce the socioeconomic impacts of climate change and strengthen community resilience through sustainable livelihoods. It contributes specifically to policy's outcome 1 (reduced vulnerability through improved social, economic, and ecological resilience) and outcome 3 (increased awareness of climate change impacts, adaptation, and mitigation measures). The study also contributes to the Global Sustainable Development Goals (SDGs),

which emphasize the interconnectedness of environmental, social, and economic dimensions. It specifically addresses SDG 1 (No poverty), SDG 2 (Zero hunger), and SDG 13 (Climate Action), underscoring the importance of empowering fishing communities to make them well-adapted to climate change impacts, thus alleviating poverty and hunger. The study also aligns with the Malawi 2063 (MW2063) vision of transforming Malawi into a wealthy, self-reliant, industrialized 'upper middle-income country' by 2063 (NPC, 2020).

The study addresses key enablers for economic independence and high-quality life for all citizens, including enabler 1 (mindset change), enabler 5 (Human capital development) and enable 7 (Environmental sustainability). Building resilience to climate change require consolidated efforts from scientists, policymakers, government and resource users, in this case, fishermen. These players should work together to assess opportunities within the institutional and scientific structures to provide entry points for local fisher knowledge to make contributions. This leads to understanding local communities' vulnerability and coping mechanisms therefore incorporating adaptation measures into development policies for sustainable resilient livelihoods. This paper demonstrates rural communities' perception of climate change, its impacts on fish catches and livelihoods, and how these communities cope with such changes.

CHAPTER TWO: LITERATURE REVIEW

2.1 Conceptual framework of the study

This study was framed around the vulnerability and perception conceptual frameworks which have been used in numerous studies on climate change to assess the causes of climate change, the impacts of climate change and the adaptation measures to climate change (Smit and Wandel, 2006; Füssel, 2007; Allison *et al.*, 2009; Limuwa *et al.*, 2018). The vulnerability framework is viewed as a function of exposure to a shock, the degree to which local communities have been exposed to environmental dynamics, and their capacity to withstand the shock (Gallopín, 2006; Sonwa *et al.*, 2012; Joakim *et al*., 2021). The perception framework is used to consider the psychological mechanisms that prompt people to alter their behavior in response to climate change (Eagly and Chaiken, 1993). This study used various research techniques to evaluate the vulnerability of Malawi's small-scale fishermen and their coping strategies, utilizing perceptions as a foundation to assess their view on the impacts of climate change.

Exposure is the nature to which a system is subjected to significant climatic variations or extreme weather events due to global environmental changes (McCarthy, 2001). In this study, we used changes in temperature, winds, water level and rainfall as the exposure component indicators which affected the fisheries sector by causing biophysical and socioeconomic impacts. Sensitivity is the degree to which a system is affected either adversely or beneficially by climate-related stimuli, and it is associated with changes in the number of fishers, fish catches and fishing distance. Lastly, adaptive capacity is the ability to adjust to stressors or shocks, which can be planned or spontaneous (Downing *et al.*, 2001). Despite that the focus of this study was solely on climatic variables and how they affect various assets, it is crucial to remember that systems are also

susceptible to other variables that are not related to the weather, such as weak governance, overfishing, usage of illegal gears and poverty which also affect how exposed, sensitive, and adaptable communities are (Adger *et al.,* 2007).

This study conceptualized perception by examining how local fishing communities in Lake Malawi have responded to changes in the environment and available resources. This sensation results from the memory's ability to recall earlier occasions, which serves as a point of comparison for the resource's current state and the outcome of such behavior may lead to maintaining the current state of things or adjusting (Ayeri *et al.,* 2012; Nkomwa *et al.,* 2014). Perception is considered subjective and comprises a wide range of things which are contextual, value-laden and dynamic therefore, the description of the same event may vary among people in the same environment (Heathcote, 1969; Ingold, 2021). Therefore, Broadhead and Howard (2011) pointed out that validating knowledge gained through perception is essential because it can potentially be deceptive. In this study, perceptions were validated using accepted scientific knowledge from the meteorological services and Department of Fisheries.

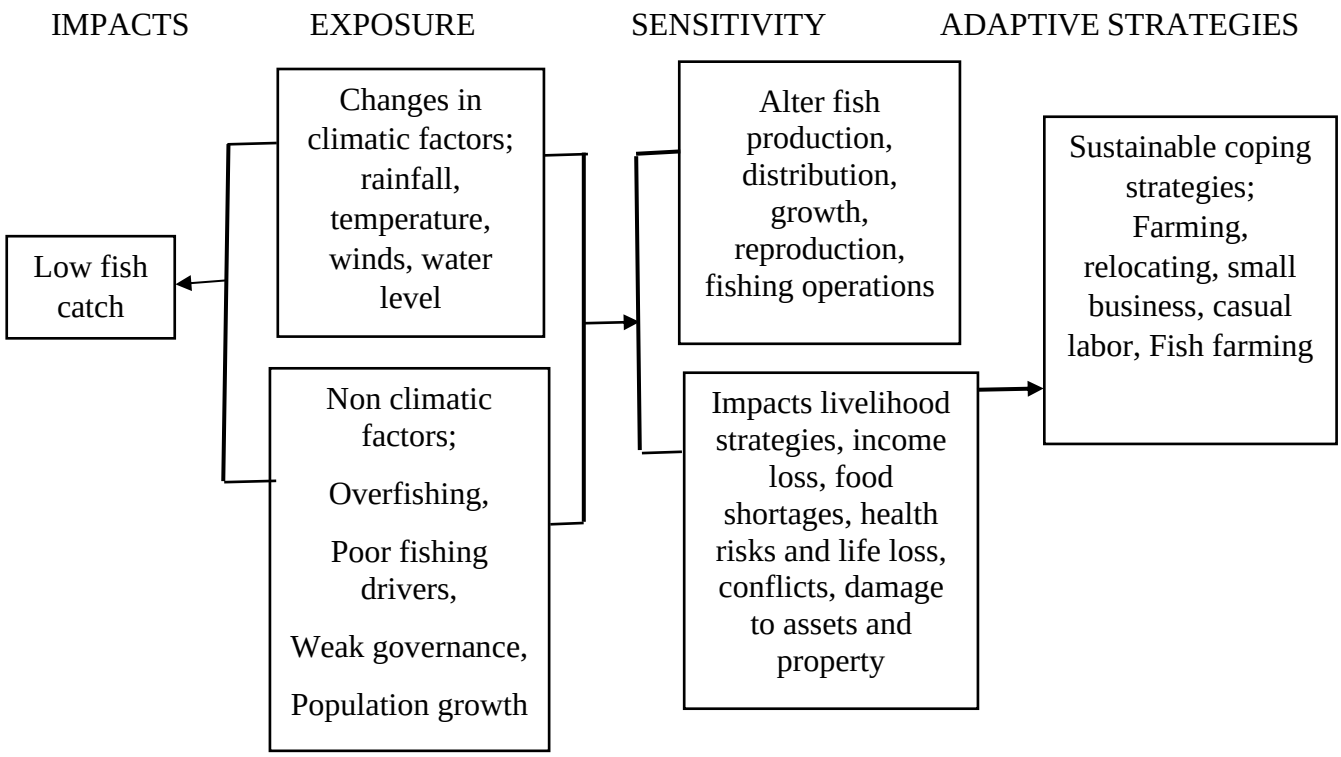

Figure 1: Vulnerability—perception conceptual framework of the study (adapted from Taylor *et al.,* 1988)

2.2 Perceptions of climate change

Individuals' perceptions of climate change are shaped by a myriad of personal factors, including their unique experiences, recollections of past climatic events, beliefs, trust in information sources, environmental attitudes, concerns, as well as social, geographical, and cultural influences, among others (Patt and Schröter, 2008; Van der Linden, 2015; Whitmarsh and Capstick, 2018). Climate change, despite its profound implications on the environment, society, and the economy, remains a challenging concept for the general public to accurately and readily grasp. These difficulties arise from several factors for instance climate change unfolds gradually over time, making it less perceptible in the day-to-day experiences of most individuals (Weber, 2010). Additionally, human recollections of past climate-related events can be fallible and imprecise. Furthermore, many

people do not consistently differentiate between the concepts of climate and weather, further complicating the understanding of climate change (Rosell, 2011). Conversely, Weber (2010) contended that despite the challenges associated with perceiving climate change, individuals can indeed gain a comprehensive understanding of it through their own experiences and observations.

Research on the public's perception of climate change consistently demonstrates that a significant portion of the population has already recognized the presence of climate change (Leiserowitz, 2006; Thomas *et al.*, 2007; Akter and Bennett, 2011). Many of these studies reveal that personal life experiences play a significant role in shaping this perception. Individuals who have directly encountered the impacts of extreme climatic events tend to express a heightened awareness of the likelihood of such events occurring again in the future (de Matos Carlos *et al.*, 2020). In addition, Weber (2010), emphasized that an individual's perception of climate change can be influenced or even revised by the information they receive. Recent studies have had an increasing realization that local people are a valuable source of information because not only are locals keen at observing climate changes but they are actively trying to adapt to the changing conditions (Ishaya and Abaje, 2008). Habiba *et al*. (2012) indicated that local people's perceptions of climate change shows that they have observed changes in climatic patterns in recent years, especially in rainfall and temperature. However, Tripathi and Mishra (2017) reported that although locals are aware of temperature and rainfall change, they fail to recognize these changes as climate change.

Many Africans are well-informed about the shifting weather patterns, and individuals whose livelihoods are intimately tied to natural resources, such as fishermen, possess a heightened level of knowledge and awareness concerning climate change (Taderera, 2010). Fishers are likely to

regard climate change as a problem because of their close ties to aquatic ecosystems and their vulnerability to environmental change. For instance, some fishers in Malawi attributed floods and decrease in lake water levels as an indicator of climate change (Limuwa *et al.,* 2018). Although fishermen possess an awareness of climate change, research reveals that they often perceive climate change as a lesser concern when compared to other challenges, such as financial pressures or managerial decisions within the fisheries sector (Tingley *et al.*, 2010; West and HoveLsrud, 2010; Nursey-Bray *et al.*, 2012). According to Bennett *et al.* (2014), fishermen may occasionally notice changes in fisheries and fish catches caused by changes in climate, but they may not always ascribe these changes to climate change nor do they use that knowledge to prepare themselves for the repercussions. In addition, Zhang *et al*. (2012) highlighted that fishermen also demonstrate skepticism toward the intensity of the impacts of climate change, the trend in warming, and the rate of human involvement in issues or information about climate change. The challenge fishers face in accurately perceiving climate change is compounded by the diversity of their experiences, which are shaped by various factors including the unique characteristics of coastal areas. These variations in how climate change is experienced give rise to differing perceptions and levels of adaptation that vary from one region to another (Mulyasari *et al.*, 2023).

Prager and Posthumus (2010) proposed that perceptions of climate change exhibit diversity, dynamism, and distinctiveness, primarily shaped by factors such as education, age, gender, geographic location, socio-economic standing, religion, cultural background, historical experiences, and the availability of information. For instance, small-scale fishers of Sanyinthi fishing basin had misperceptions of climate change due to lack of access to weather information which resulted to poor adaptation measures because fishers relied on local environmental

indicators and weather events to understand current and future weather patterns (Mafongoya *et al.*, 2019). A study of perception conducted in Fiji confirms that misperceptions of climate change can lead to maladaptation (Lata and Nunn, 2012) and cause a disconnection between the actual and perceived risk.

Research shows that fishers may downplay risks or be resistant to the idea that climate change poses significant changes due to their fearlessness and ability to cope in a constantly challenging environment (Edvardsson *et al.*, 2011; Nursey-Bray *et al.*, 2012; Dannevig and Hovelsrud, 2016). However, low-risk perceptions and skepticism about climate change might make people less inclined to support programs or laws that address the issue and lessen their readiness to respond to its effects (Hidalgo *et al*., 2010). Perception of climate-related risks is subject to various influences, including psychological factors, cognitive processing, sociocultural dynamics, and socio-demographic attributes (Whitmarsh, 2011; Hornsey *et al.*, 2016). Therefore, it is of utmost importance to acknowledge these contributing elements to better understand how to communicate risks effectively and to account for the individual variations in perception that can lead to differing responses in terms of adaptation (Grothmann and patt, 2005).

2.2.1 Climate Change and Climate Variability

According to the IPCC (2018), climate change is characterized as a sustained alteration in climate patterns resulting from the release of greenhouse gases, leading to the accumulation of heat in the Earth's atmosphere. This, in turn, has consequences for more than just shifts in weather but it also encompasses prolonged variations in seasonal conditions (IPCC, 2007). Climate change entails modifications in temperature, precipitation, humidity, wind patterns, and seasonal rhythms. These

alterations in climate patterns play a pivotal role in shaping natural ecosystems and the human economies reliant upon them. As a result, climate change has emerged as one of the central phenomena posing a global threat to both life and humanity since the onset of the Industrial Revolution (Abubakar *et al.,* 2009). Many developing countries, particularly in Africa, are seen as being most vulnerable to climate variability and change (Wheeler *et al.,* 2005), and Malawi is one of these countries. This vulnerability is chiefly rooted in the expectation that climate change will exacerbate the preexisting challenges related to food security, health, poverty, and overall development in these regions (USAID, 2013).

Malawi is vulnerable to climate change due to its extensive reliance on rainfed agriculture and its low adaptive capacity (CIA, 2017). Alarmingly, approximately 60% of the population is categorized as food insecure (MMNRE, 2006; Douillet *et al.,* 2012). Numerous studies have highlighted the significant economic repercussions of climate-related shocks, such as floods and droughts, in the country. These events disrupt agricultural exports and food security, particularly given that a substantial portion of the country's agricultural output comes from smallholder rain-fed farming (FAO, 2010; Pauw *et al.*, 2010; MAFS, 2011). For example, the 2005 drought left 40% of the population in dire need of immediate food assistance (Giertz *et al.*, 2015).

2.3 Perception on climate change impacts on fisheries and fishing activities

Understanding the perceptions of fishers on the effects of climate change and adverse weather events on fisheries and their livelihoods is an important basis on which to build climate change adaptation and mitigation measures. Several studies have shown that fishing communities are able to highlight the relationships between climate change and changes in fisheries and fish catch

(Arantes *et al.,* 2013; Lusardi *et al.,* 2016; Whitney *et al.*, 2016). According to Muringai *et al*. (2022) fishers in Lake Kariba indicated that climate change have affected the freshwater ecosystem and the livelihoods of the fishery-dependent households. The fishers reported that drought events can have severe effects on freshwater fisheries such as disturbing fish habitats, fish physiological functioning, spawning, and fish assemblages. Furthermore, fishers perceive that floods and strong winds cause damage to fishing gear, disrupted fishing schedules, and sometimes lead to injuries or loss of lives (Westlund, 2007; Musinguzi *et al.,* 2016). Additionally, fishers in Tam Giang Lagoon, Vietnam state that floods damage their fixed fishing gear, such as bottom nets and coral nets (Ha and Thang, 2017). Fishers in Lake Kariba associated being injured and the loss of lives with strong winds that increase the severity of waves, for instance, the most violent wave locally known as the "Binga wave", which capsizes boats leading to drowning and loss of life.

Fishers indicated that climate change leads to the declining of fish stocks by causing changes in the fish species composition and causing fish diseases. The decrease in fish stocks due to climate change was also attributed to decrease in the profits obtained from fisheries (Mafongoya *et al.,* 2019). Fishers also perceived the shrinking and disturbance of fishing grounds and food insecurity as a result of climate change. The majority of the fishers reported climate change as the main driver of low fish catches and species composition changes. Low fish catches were attributed to droughts, erratic rainfall, strong winds, extreme hot temperatures and flooding. Fishers indicated having to travel further to increase the catch, catch decline, distribution pattern changes and decline in growth of corals (Brown *et al.*, 2012). Numerous studies have been done to understand the impacts of climate change on fisheries and fishing communities in Lake Tanganyika, Lake Malawi, Lake Kivu and Lake Chad however, the knowledge gained is specific to the ecosystem of each locality

therefore, it is important to undertake site specific research to capture micro-level perception of the impacts of climate change on communities in the ecosystems vicinity (Tshuma and Mathuthu, 2014; Limuwa *et al.*, 2018)

2.3.1 Relationship between climate variables change and fisheries production

The fisheries sector is fundamental to the development of Africa through its contributions to alleviating poverty, promoting socioeconomic growth and improving the livelihoods of the poor and marginalized communities (Chan *et al.*, 2019). However, climate change and variability are rapidly impacting aquatic ecosystems, including marine, fresh and brackish waters adversely. Climate change and climate variability have intensified and affected natural resources through their influence on precipitation, water availability and habitat change (Daw *et al.*, 2009). Climate change affects aquatic environments by altering stratification, circulation dynamics, loading and recycling of nutrients and dissolved oxygen levels (Verburg *et al.*, 2003; Vollmer *et al.*, 2005; Marshall *et al.*, 2009; Tshimanga and Hughes, 2012). These environmental changes play a significant role in influencing the distribution, migration and productivity of fish since fish are sensitive organisms, and changes in the water quality impact their population (MOEFCC, 2018).

The impacts of climate change and climate variability on fisheries cannot be generalized as the sector is affected in several pathways classified as; biological, physical and socioeconomic effects (Muringai *et al.*, 2021). Therefore, there is great uncertainty regarding the extent and speed of climate change and the knowledge of its biophysical impacts on fish stocks. Furthermore, the uncertainty extends to understanding how human populations and economic systems react to climate-induced changes. Evidence of the impacts of climatic events on fish yield and availability

has accumulated. For example, the number of fish species in Lake Chad decreased from 40 to 15 tons between 1971 and 1977 following a drought ((Lévêque, 1995). Fish yield in Lake Chilwa decreased to zero in 1996 following the desiccation of the lake (Allison *et al.*, 2007; Njaya *et al.*, 2011). The yield of *Limnothrissa miodon* (Boulenger) in Lake Kariba decreased at an average of 24 metric tons per year between 1974 and 2003 with associated changes in rainfall and water levels (Ndebele-Murisa *et al.,* 2011).

The fluctuations in the catches of large commercial fish have adverse consequences for both the livelihoods of fishermen and the management of fisheries. This is because some fishermen tend to capture smaller fish, as was observed in Uganda. In this context, the contribution of less economically valuable small fish species, such as *Rastrineobola argentea (*Pellegrin) in lakes Victoria and Kyoga increased between the years 1978 to 2008, and in West Africa the pelagic fisheries for *Sardinella aurita Valenciennes* 1847 increased (Binet *et al*., 2001; Ogutu-Ohwayo *et al.*, 2013). This aligns with the forecast made by the (FAO, 2010), which predicts that climate change will lead to a shift in fisheries towards smaller, fast-growing, opportunistic species.

2.3.2 Socioeconomic impacts of Climate Change

Climate change is expected to impact countries' economies, fishing communities and fishers through a diverse range of pathways. Fishers face the consequences of climate change at the point in which it impacts their livelihood and fishing activities thus, affecting the communities and country at large (Daw *et al.*, 2009). The effects of climate change add an additional layer of hardship to the array of factors contributing to poverty within fishing communities, including diminishing fish stocks, conflicts, health issues, the absence of savings, insurance, and alternative means of livelihood (Barange *et al.*, 2018). Fishing communities across Sub-Saharan Africa have

already been recognized as exceptionally susceptible to the impacts of climate change. This vulnerability arises from their heavy dependence on climate-sensitive resources for their livelihoods. Furthermore, the limited capacity of Sub-Saharan African national economies to effectively address the consequences of climate change further exacerbates their vulnerability (Belhabib *et al.*, 2016).

In Malawi, fisheries play a crucial role in providing food, nutritional security, a source of income, subsistence, and employment to both the rural and urban impoverished communities (FAO, 2014). Many coastal societies of developing countries are today, however, experiencing extreme fluctuations in fish landings as a consequence of climate change and global anthropogenic pressures from e.g. overfishing, loss of habitats and use of destructive fishing methods (Jackson *et al.*, 2001; Brander, 2007; Cinner, 2009). These changes are expected to not only impact fisheries landings but also the millions of people depending on fish for income and food security. Small-scale fishers in Lake Kariba have acknowledged that the diminishing fish catches have hurt their income, as fisheries represent their primary source of income, food and sustenance (Saito *et al.*, 2017). In Malawi, the consumption of dietary animal protein from fish, declined to 40% from about 70% in the 1980 (Banda *et al.,* 2005). Obiero *et al.* (2019) and Tran *et al.* (2019), reported that fish stands as a critical and affordable source of animal protein for over 200 million people in Africa.

Small scale fishers are also exposed to direct climate change impacts because they live in lakeshore communities and are at risk from damage to property and infrastructures from multiple direct impacts such as water level rise, flooding, storm intensity and frequency (Daw *et al.*, 2009).

Worsening storms also increase risks associated with working at sea and changes in weather patterns may disrupt fishing practices that are based on traditional knowledge of local weather and current systems causing fishers to enter the waters fishing on days that storms can occur resulting to injury or death of fishers. Furthermore, Nicholls *et al*. (2007) reported that extreme climate events such as floods and strong winds damage fishing vessels and shore-based infrastructures such as city ports and other fishing facilities which affects fishers' livelihood and safety.

The consequences of climate change will also have far-reaching implications for the economies of countries at national and regional levels. However, the extent and direction of these impacts can diverge among regions, communities, and families. According to Lam *et al.* (2016), it is anticipated that the economic output of West Africa's fisheries will witness a 10% decline due to climate change. The study further expounded that, in the face of climate change, the economic output of fisheries is expected to decrease in countries situated within Guinea's Current Large Marine Ecosystems, including Nigeria, Sierra Leone, and Equatorial Guinea. On the contrary, an increase in economic output is projected for countries within the Canary Current Large Marine Ecosystems, such as Gambia, Mauritania, and Senegal.

Most Sub-Saharan African countries' fisheries are negatively impacted by climate change, making it more difficult for the sector to supply the region's expanding demand for fish products thus impacting the country's economy. This decline is reinforced by the fact that Malawi's per capita fish supply plummeted by 60% by 2011, falling from 14 kilograms per person per year in the 1970s to approximately 5.7 kilograms (FAO, 1993; FAO 2012). According to the United Nations Conference on Trade and Development, fish is one of the highest-value traded commodities, which

accounts for approximately 10% of agriculture exports globally (UNCTAD, 2017). Developing countries account for about 53% of global fisheries exports, followed by developed countries and then least developed countries, which account for 43% and 4%, respectively. Therefore, fluctuations in fish catches will not only impact fishers' livelihood but also the country's economy at large.

2.4 Coping strategies and adaptive measures

The majority of the global fisherfolk, approximately 200 million individuals, reside in regions that are exceptionally susceptible to the impacts of climate change. Fisherfolk livelihoods are significantly intertwined with resources that are influenced by fluctuations in climate (Allison *et al.*, 2005). The fluctuating nature of fisheries poses unique challenges for people's livelihoods that depend on the resource for income. However, residents of fishing communities are often adaptable and employ various strategies to cope with these fluctuations (Mvula, 2002). Climate change adaptation refers to the discrete actions taken to adjust to actual or expected climate and its effects and seeks to moderate harm or exploit beneficial opportunities in human systems (Agard *et al.*, 2014). Adaptation to climate change requires that communities first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison, 2007). In addition, Eakin *et al*. (2014) indicated that adaptation requires not only that individuals perceive that something is changing or could change, but also that they attribute enough weight to this perception to be willing to take action.

In this sense, perceiving that the climate is changing can be seen as a precondition for adoption of climate change adaptive measures (Simelton *et al.*, 2013; Makuvaro *et al.*, 2018) and this is crucial

in communities whose livelihoods depend directly and heavily on natural resources such as the fisheries and agricultural sector (Asfaw *et al.*, 2016). In order to maintain their way of life, fishermen have been employing a variety of adaptation strategies to address the consequences of climate change, with the specific measures adopted often varying depending on the location and availability of resources (Muringai *et al.*, 2022). For instance, in response to the effects of climate change, fishermen in Lake Wamala, Uganda, have started modifying fishing gears, dedicating more time to fishing, shifting their focus to new species, and diversifying into non-fishery-related livelihoods (Musinguzi *et al.*, 2016). Similarly, in Kenya, fishers have benefited from upgrading their fishing equipment, enabling them to target new species that have replaced their declining original catches. This diversification has expanded the range of fish species they can catch, ultimately increasing catch per unit effort (CPUE) (Selgrath *et al.*, 2018).

Small-scale fishers in West Africa and in Mauritania specifically have responded to the challenge of reduced fish catches by substantially expanding the size of their fishing grounds and increasing their fishing effort, with an average increase of 500% in West Africa and approximately 900% respectively (Belhabib *et al.*, 2016). Furthermore, in an effort to cope with declining fish catches due to the shifting of target species, fishermen in West Africa have relocated to different fishing areas within the exclusive economic zones of the region. Investigations into the livelihoods of small-scale fisheries consistently underscore the importance of migration and diversification of livelihoods as fundamental adaptive strategies in the fisheries sector. Coping strategies can be divided into two main categories: proactive and reactive approaches (Makwinja *et al.*, 2021). Proactive strategies, as described by Salas *et al.* (2011), encompass a set of preventative actions taken by households to reduce vulnerability before a shock or crisis occurs. For example, when

the fishery in Lake Malombe eventually collapsed, some fishermen proactively sought new sources of income by engaging in activities such as agriculture, small-scale irrigation along the shoreline, and floodplain farming. Others explored entrepreneurship opportunities, while some chose to join cooperatives that could provide support during periods of low fish catch. Furthermore, in the case of Lake Chilwa, fishing communities were compelled to cultivate on marginal areas within the district as a proactive adaptation measure to low fish catches (Jamu *et al.,* 2003).

Contrary to taking proactive measures, certain fishers' resort to reactive coping strategies that may yield short-term benefits but can lead to unsustainable fishing practices in the face of climate change impacts. These practices, in turn, can diminish the resilience of the ecosystem, reducing its ability to support livelihoods and ensure food security (Musinguzi *et al.*, 2016). For instance, fishers in Lake Wamala altered their fishing gear by reducing the mesh size from 88.9 mm to 38.1 mm, resulting in the capture of non-target species and juveniles (Selgrath *et al.,* 2018). According to the available research, some of the short-term strategies adopted by fishers to deal with the effects of climate change, included migration, switching to different fishing gear, focusing on new species, and utilizing social networks (Sievanen, 2014). It's also fascinating to observe that not all households in the communities are affected equally by fisheries fluctuation and that not all changes are unfavorable leading to variations in the choices on how to adapt.

Allison and Mvula (2002) observed that the successful fishermen (gear owners) who had more extensive gardens produced more cash crops during dried-up seasons of the lake (Lake Chilwa), while not well-to-do fishers such as crew members suffered because they couldn't afford agricultural inputs such as fertilizer, in turn, they resorted to short term measures such as migration.

In this context, proactive and reactive adaptation measures involve responding to challenges and capitalizing on new opportunities (Cozzolino *et al.,* 2018). Adaptation strategies for dealing with the impacts of climate change vary based on factors such as income, asset ownership, ethnicity, and the length of residence in a particular area (Agnew, 1979). Some of these adaptation techniques employed by fishermen can come with higher financial costs. For example, increasing fishing efforts by adding more boats and extending fishing ranges will elevate the overall fishing expenses. This includes the need for additional investments in new boats and increased spending on fuel to access new fishing areas (Belhabib *et al*., 2016). Panayotou (1982) proposed that fisherfolk should diversify their rural livelihoods by engaging in various income-generating activities that allow them to switch between occupations seasonally or over the years. This strategy involves maintaining a portfolio of different household income sources to enhance resilience and adaptability.

The capacity of fishers and fishing communities to adapt to disruptions or challenges in fisheries significantly influences the formulation of government policies and the pursuit of alternative livelihoods (Bunce *et al.*, 2010). According to Heltberg *et al*. (2009), to build effective adaptation measures, it is necessary to comprehend how disparities in food distribution and income interact to generate opportunities and expose vulnerable populations. Furthermore, as reported by Agrawal (2010), communities and households have developed various adaptation strategies over the years, as discussed earlier. However, the effectiveness of these adaptation efforts is contingent upon how institutions govern and organize their interactions with both internal and external stakeholders. Therefore, institutions play a crucial role in facilitating adaptation to climate change and its associated variability.

The reviewed literature highlights increasing research on fishing communities' perceptions of climate change, its impacts on fish catch and fishers' livelihoods and their coping strategies. Studies indicate that fishers generally recognize climate change and its effects on fisheries however, perceptions vary due to limited access to weather information and skepticism among communities about climate change. Additionally, most research focuses on environmental impacts of climate change with less attention to socio-economic dimensions, including the role of traditional knowledge, resources, and institutional support in adaptation. While studies recognize adaptive strategies such as livelihood diversification and modified fishing techniques, there is limited understanding of how social factors influence their adoption. This study addresses these gaps by examining how adaptive strategies, such as resource diversification and agriculture ventures, enhance resilience in fishing communities. By bridging these knowledge gaps, the study contributes to ongoing debates on climate change adaptation and informs policies for strengthening community resilience.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

The study was conducted at three fishing communities in Karonga district: Ngara, Chipamira and Chiwondo. Karonga district is in the northern religion of Malawi, bordered by Chitipa district in the west, Rumphi district in the south and Tanzania in the north-east. The district has 365,000 people according to the 2018 census and covers a total land area of 3355 square kilometers (NSO and ICF, 2017). The district has a sub-tropical climate with two distinctive seasons, rainy/wet (November to May) and dry (June to October). The warmest months are October and November, with an average yearly temperature of 24°C, whereas June and July experience milder temperatures 17°C. (Karonga District Meteorological Office, 2013).

Karonga district was purposively chosen for this study because it is one of Malawi's most disaster-prone districts, experiencing increasingly erratic rainfall and seasonal flooding. The district is vulnerable to earthquakes, floods, strong winds and drought and registered the most significant number of catastrophes in Malawi between 1946 and 2008 (Runduka *et al.*, 2010). Furthermore, the study area is one of the areas in the country where fishing is the primary source of livelihood. Therefore, any changes in the lake occasioned by fish stock fluctuation are likely to impact the fishing community's livelihood. The district is located along the shores of Lake Malawi, and more than 5,000 people carry out fishing-related activities. Small-scale fishers dominate fishing activities and contribute 60% of animal protein for Karonga district (GoM, 2016).

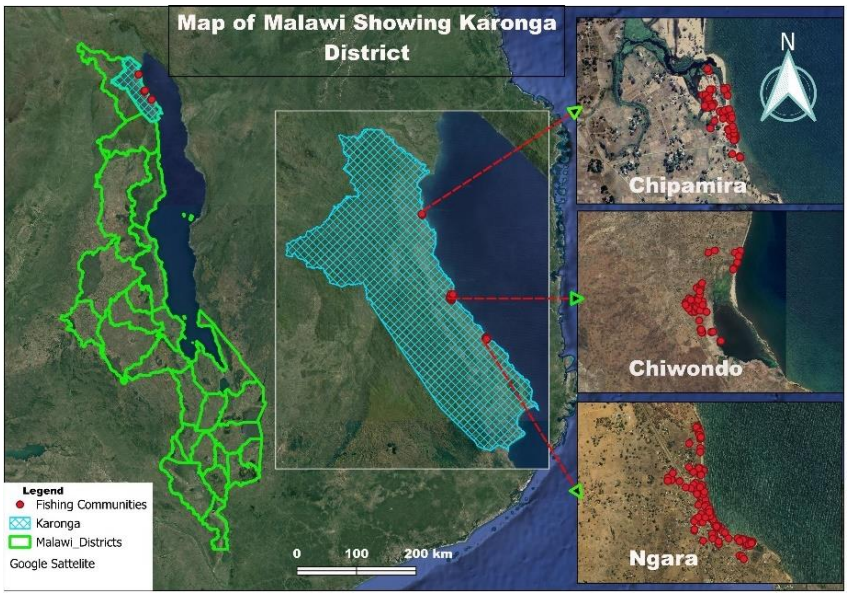

Figure 2: Map of Malawi showing Karonga district and the study area, generated using QGIS software

3.2 Research Design

The study used a mixed-method research design using both qualitative and quantitative methods to collect and analyze data. Mixed method research is a valuable model for social science research as it can potentially capitalize on the respective strengths of qualitative and quantitative approaches (Bryman and Cramer, 2012). A mixed-method approach was used in this study to explore the relationship between climate change impacts and the resilience of fishing communities. Qualitative methods, such as interviews and focus group discussions, provided an understanding of the local dimensions and responses to climate change and adaptation strategies. Meanwhile quantitative methods, including surveys and statistical analysis, measured communities' awareness to climate change, its impacts on fish stocks, fishing practices, livelihoods and coping strategies. By combining these approaches, this study captured both detailed, context-specific insights and broader patterns, making it ideal for analyzing climate change adaptation in Karonga district.

3.3 Sampling procedure

The study applied purposive sampling for the selection of participants. Respondents were chosen based on their profession, years stayed in the location, age and fishing experience. The study sampled individuals who have lived in the area for more than 10 years, fall within specific age ranges 30-60 years and had been involved in fishing for more than 10 years. According to Marx *et al.* (2007) and Limuwa *et al.* (2018) using age, fishing experience and years of residency as criteria, allows researchers to focus on participants who are likely to provide valuable insights related to climatic changes and impacts. A Slovin's formula was used to determine the sample size in each study site to which the household survey was administered using the equation below;

$$n = N/1 + N(e^2) \qquad (1)$$

where: n= desired sample size, N= population size, e= error tolerance

The survey was administered to 311 fisher households in three fishing communities.

3.4 Data Collection

The study used both primary and secondary data, which was collected between the months of January and February 2024. Primary data was collected by conducting a household survey using a semi-structured questionnaire, Focus Group Discussions using a guide (FGD), and key informant interviews using a checklist (KII). The questionnaire for the survey was divided into four sections; household characteristics and composition, household fishing data, perceptions on climate change and its impacts on fisheries, and coping strategies. The initial semi-structured questionnaire was developed based on literature review and was pre-tested at Kaporo beach in Karonga to ensure that the questions included were clear, understandable, and would yield relevant information. The study

targeted fishers, fish processors and traders, local fishery conservation groups (Beach Village Committees) and village management structures.

During data collection, interviews were administered in the local languages of Chichewa, Tumbuka and Tonga, and the responses were translated into English for data analysis. A total of four focus group discussions and three key informant interviews were conducted to gain in-depth knowledge on climate change and its impacts on fisheries. Observations were made using a checklist on various livelihood activities carried out in the area, and the information was recorded in a record sheet. Document analysis was conducted to gain insights on existing knowledge on fish catch trends and climate trends in Karonga district. The study also used secondary data to validate fishers' perceptions of climate change and fish catch changes. Secondary data on climate change indicators (temperature and rainfall) for over the past 30 years was obtained from AQUASTAT, FAO climate information tool. And long-term data on fish catch for the past 30 years was collected from the reports at the District Fisheries Office.

3.5 Data Analysis

The study used multiple analytical methods to analyze primary and secondary data. Data collected was analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0 software and Microsoft Office Excel 2019.

3.5.1 Qualitative Analysis

Quantitative and qualitative data from the household survey, focus group discussions and key informant interviews were transcribed, translated into English and analyzed using thematic

analysis for related themes. The analysis involved converting spoken words, either audio recordings from interviews, focus groups, or other sources, into text which ensured that the data was in a format that could be analyzed and interpreted. Then, the data was broken down into manageable units by identifying recurring themes or concepts and extracting meaningful information using thematic analysis, which helped in reducing the complexity of the data. Identifying related themes was based on recorded patterns within the data guarded by the research questions. The themes identified included examining the awareness of fishing communities to changes in climatic parameters, their awareness to climate change impacts on fishery resources and livelihood and their coping strategies to the identified challenges. In order to support and clarify the perceptions of different respondents interviewed, direct quotations were also used.

3.5.2 Quantitative Analysis

Various quantitative methods were used to analyze household survey data and data collected from secondary sources such as temperature, rainfall, and fish catch data. Household survey data from the sampled respondents was analyzed using descriptive statistics (means, ranges, frequencies and percentages). Trend analysis was used to establish the presence of trends in precipitation and temperature of the meteorological time series data and also for the fish catches data. On the other hand, inferential statistics was used to assess whether relationships exist between specific respondent characteristics and the fishing environment. A binary logistic regression was conducted to identify the key explanatory variables that have the probability to influence whether fishers adapt to the impacts of climate change. The model aimed to determine which factors significantly predict whether fishers develop coping strategies in response to climate-related challenges, such as low fish catches.

The binary logit model was used because it is a cumulative distribution function that analyzes observational data, and the study collected observation data (Rahm and Huffman, 1984; Gujarati, 1995). The model was used to identify the factors affecting the fisher's adaptation to low fish catch. The dependent variable in this model is binary or dichotomous, with only two discrete outcomes since the fisher only falls into one category and not both. A logit model guaranteed the estimated probability increases and never cross the range of 0 to 1 (Uddin *et al.,* 2014). Respondents were asked, "In the face of low fish catches, what are your adaptive measures?". Answers for 'farming, small-scale business, livestock farming, etc.' will represent 'coping', whereas answers for 'nothing, waiting, still fishing etc.' will represent 'no coping'. The probability of fishers adapting to low fish catches ranges from 0 (coping) to 1 (no coping)

The logit model was specified to the following equation:

$$P_i = \beta^0 + \beta^1 X^1 + \beta^2 X^2 + \ldots + \beta_p X_p + \mu_i \qquad (2)$$

Where: P_i is the probability of coping to low fish catches and it ranges from 0 (coping) to 1 (no coping), β_0, β_1, β_2, ..., β_p are the coefficients (or parameters) estimated by the model, X_1, X_2, ..., X_p are the independent variables (explanatory variables) and μ_i is the error term.

The selection of explanatory variables used in this study was based on the availability of data and guided by current literature on adaptation to climate change.

A Pearson Correlation analysis was conducted to determine whether any relationship exists between the mean annual temperature and total annual precipitation and fish catches. A Pearson correlation is used to measure the association or relationship between two variables to ascertain

whether they are positively or negatively related (Obilor and Amadi, 2018). The formula for measuring correlation was presented in the equation below:

$$rxy = \frac{=\sum xiyi - nx^{-}y^{-}}{(n-1)sxsy} \qquad (3)$$

Where: rxy = correlation; xi and yi = sample means of variable x and y; sx and sy = standard deviations of x & y.$_x$

The correlation coefficient measures the strength of association between two variables. It can be high or low (magnitude) and positive or negative (direction). The coefficient ranges from -1 to +1, indicating a negative or positive correlation, respectively, and 0 implies no correlation.

3.6 Ethic Consideration

Informed Consent was obtained from the Mzuzu University Research Ethics Committee (MZUNIREC) before the commencement of the data collection. Permission from the Department of Fisheries and Karonga District Fisheries Office was acquired before the research began to select fisher's households. Permission was granted by various village chiefs to conduct research in their areas. When requesting permission, the objectives and purposes of research were communicated to the subjects as academic but important to influence policy formulation. The other informed consent was solicited during household survey interviews, Focus Group Discussions (FGD) and Key Informant Interviews. Lastly, data from various authors and researchers that was exported into this study is acknowledged using references.

CHAPTER FOUR: RESULTS

4.1 Demographic Characteristics of Respondents

The study showed Tumbuka and Nkhonde, were the predominant tribes and minority tribes included Tonga, Yao, Chewa, Swahili, Mambo, Kisi, Ndali, Sukwa, Nyawezi, and Nyakyusa (table 1).

Table 1: Demographic characteristics

Variable	Description	Percentage (%)
Age	20-30 years	2
	31-40 years	40
	41-50 years	32
	>50 years	26
Gender	Male	92
	Female	8
Educational level	No formal education	3
	Primary	68
	Secondary	27
	Tertiary	2
Marital Status	Married	91
	Single	5
	Divorced	1
	Widowed	1
	Separated	2
Tribe	Tumbuka	54
	Nkhonde	35
Monthly Income	< 100,000 MK	36
	100,000-500,000 MK	55
	>500,000 MK	9

Most respondents (97% (278 males; 24 females)) were aged 31 to 80 years, and 66% (190 males;14 females) had lived in the area for over 30 years. The study focused on older individuals and long-term residents to gather insights on weather-related changes in the community. Additionally, 55% (162 males; 9 females) of respondents had over 30 years of fishing experience, allowing them to clearly recall changes in fish catches, climate patterns and their consequent effects.

Most fishers (94%) engaged in various income-generating activities beyond fishing, including farming (maize, rice, groundnuts, cassava), selling fish, off-farm labour, small businesses, property rentals, transportation, boat repairing, net repairing, tailoring, weaving nets, formal employment and livestock farming (pigs, goats, oxen). Only 6% relied solely on fishing for income. Additionally, 36% reported a monthly income below MK100,000 from fishing, while 55% earned between MK100,000 and MK500,000 (Table 1).

4.2 Fishing communities' perception of climate factors (temperature, rainfall, lake water-level)

The majority (90%) of respondents acknowledged being exposed to extreme weather events during their stay in Karonga, such as strong winds (Mwera) (56%), floods (64%), late rains (49%), dry spells (61%), extreme hot temperatures (72%), erratic rainfall (90%) and droughts (50%). Fishers highlighted changes in both the intensity and pattern of temperature and rainfall (table 2). Notably, alterations in the seasonality of the hot season were observed over the years and extreme hot temperatures have been experienced within the district. Changes were also reported on the seasonality, frequency and intensity of rainfall, indicating substantial changes in the local climate.

Table 2: Karonga district fishing communities perceived changes in temperature, rainfall and water level

Climate Parameters	Participant's Response		
	Increase (%)	Decrease (%)	No change (%)
Temperature	90.03	5.79	4.18
Rainfall	20.26	76.52	3.22
Water level	100	0	0

Source: Fishers' perceptions survey data, 2024

During a focus group discussion on January 16, 2024, Ngara BVC members noted that temperatures in the 2000s are hotter than in the 1990s. One member explained, "*Deforestation has disrupted rainfall patterns, leading to higher temperatures. It's so hot now that people are sleeping outside*." Fishers added that while they used to anticipate hot seasons, now temperatures remain high year-round, drying out crops and disrupting their income. Respondents also noted changes in rainfall patterns and quantity over the past 30 years. Rainfall has become erratic and less intense. One fisherman stated, "*Rains used to come from November to April, but now they start late, in January or February, and are inconsistent, leading to crop drying. At times, heavy rains fall briefly, destroying crops and property and causing hunger*." This unpredictability disrupts farming planning and adversely affects agriculture and livelihoods, as expected rainy seasons now bring little to no precipitation.

The majority (64%) of the fishers acknowledged experiencing continuous droughts, and 55% of fishers reported encountering floods over the past five years. The high incidences of floods were

attributed to an increase in the lake's water level, a dominant problem in Chiwondo and Chipamira community. During a focus group discussion at Chiwondo, members alluded that "*the lake's rising water level has destroyed farms and houses, increased attacks by crocodiles and hippos, and forced community members to stay indoors by 5:30 p.m. due to fear*." Fishers from Chipamira reported periodic flooding from the Lufilya and North Rukuru river, forcing farm inundation and migration to other fishing communities. Fishers also noted change in the frequency of strong winds (Mwera). A respondent from Ngara explained, "*Since the early 2000s, damaging winds have affected property and crops. We used to predict Mwera winds from April to July, but now they occur year-round, disrupting the Usipa catch*". Persisting to fish during these winds has led to damage to boats, fishing gear and loss of lives. This is because some fishers can't wait out the winds since fishing is their only source of income.

Respondents defined climate change differently based on their time in the area, age, and access to weather forecasts. Most (82%) fishers accessed weather updates through radio, TV, phone (via *321#), churches and neighbors, influencing their perceptions of climate change. However, some fishers also relied on traditional weather forecasting methods. Most (58%) of respondents had access to extension workers from agriculture, fisheries, or meteorology. However, despite receiving weather warnings such as strong winds, some fishers still went fishing due to their immediate need for sustenance and income. Furthermore, 84% of fishermen reported not being part of any conservation committee, restricting their access to sustainable practices. Fishers perceptions of climate change causes stemmed from their direct experiences with the environment and socio-economic activities. Fishers reported deforestation, poor waste management and land use change as the main cause of climate change within the district.

Additionally, a key informant in Karonga district indicated that the meteorological department works closely with Village Civil Protection Committees (VCPC) to deliver timely weather forecasts, aiming to mitigate the effects of natural disasters in their communities. In addition, the department also holds sensitization meetings to raise awareness of early flood warnings and encourages communities to build strong houses, avoid cutting down trees, and plant early-maturing crops to withstand dry spells.

4.2.1 Rainfall

The precipitation varied across the years, with the lowest (904±165 mm) and highest (1573±181 mm) values recorded by Nyungwe and Chinsewe stations, respectively. Although a large proportion of the fishers (77%) reported decreased precipitation in the past 30 years, results indicated an increase in annual rates across the years. Contrary to the fishers' perceptions of rainfall, the meteorological time-series data showed that annual rainfall in Karonga is on the increase. The trend analysis results showed a relatively stable trend with fluctuations in specific years, indicating a slight increase in precipitation in the study area over time (Figure 3).

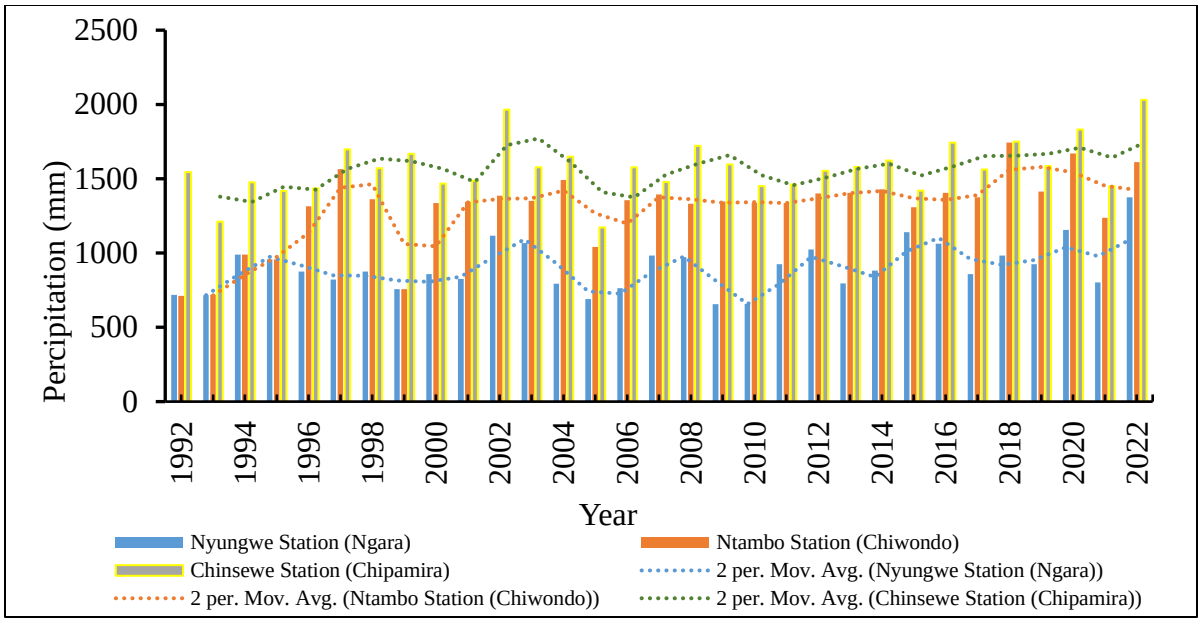

Figure 3: Total annual rainfall for Karonga district: Nyungwe, Ntambo and Chinsewe station (1992-2022) (source: AQUASTAT FAO. Climate information tool)

Precipitation anomaly for the study area (Figure 4) indicated negative and positive trends, reflecting variable precipitation.

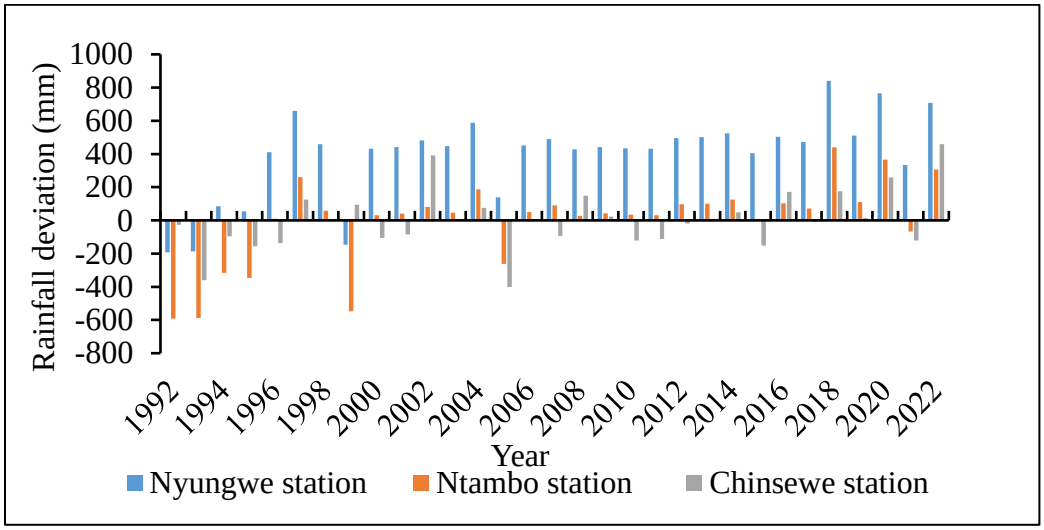

Figure 4: Annual precipitation anomalies for Karonga district from (1992-2022)

4.2.2 Temperature

Congruent to the fishers' perceptions of increasing temperatures, the results from the historical data show a relative increase in temperature between 1992 and 2022 (Figure 5). The highest and lowest average temperatures across all years were 24±0.25 ◦C and 26±10.19 °C which were recorded at Ntambo and Chinsewe station, respectively.

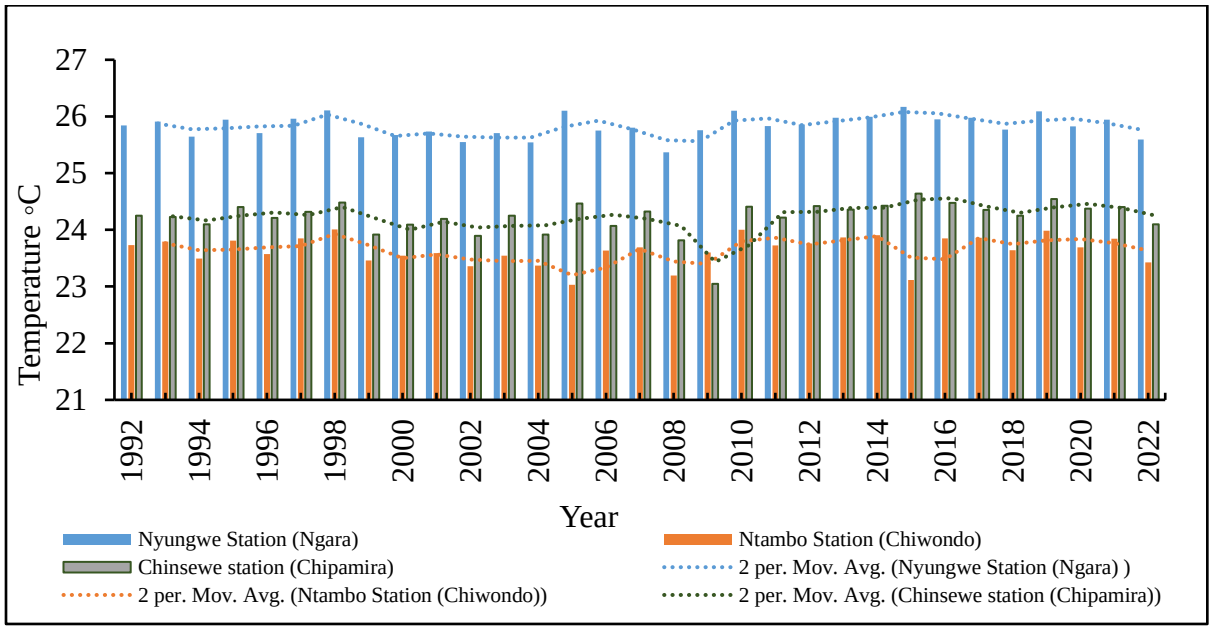

Figure 5: Mean annual temperature for Karonga district: Nyungwe, Ntambo and Chinsewe station (1992-2022) (Source: AQUASTAT FAO. Climate information tool)

The anomalies for maximum and minimum annual temperatures between 1992 and 2022 showed no defined trend (Figure 6). These results might reflect a non-stable cooling or warming pattern in the study area

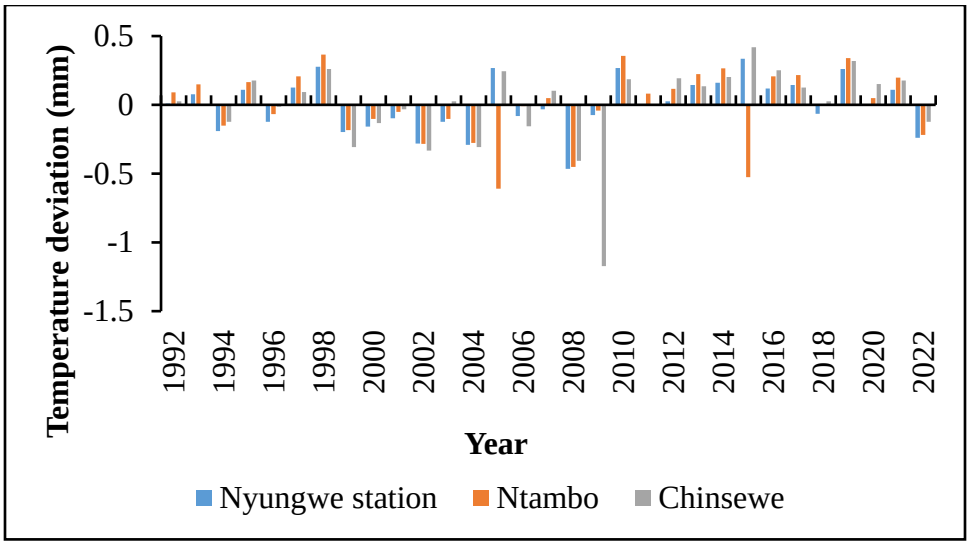

Figure 6: Annual mean temperature anomalies for Karonga district, Malawi from 1992-2022

4.3 Examining the perceived climate change impacts on fish catches

Most respondents (88%) acknowledged a decline in their fish catch over the past 30 years, and 2% reported no change. Fishers attributed the decline in fish catch to the factors highlighted in the figure below.

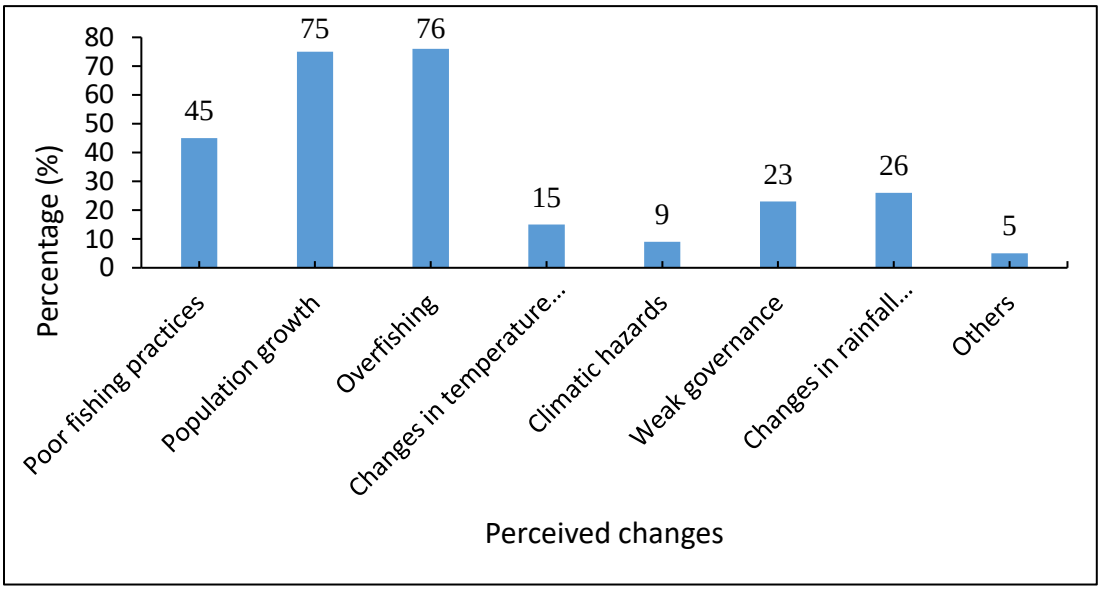

Figure 7: Perceived reasons for fluctuations in fish catches in Karonga district, Malawi

Over the past five years, 51% of respondents experienced poor fish catches due to overfishing, population growth, and climate change, while 45% had moderate catches and 4% reported high catches. One of the fishers reported "*Fishing is uncertain now; in the 1990s, there were fewer fishers, so we caught more fish. Today, nearly everyone has a boat and a gear"*.

In contrast, 10% of fishers reported an increase in fish catch in the past 30 years, which was attributed to their transition from traditional boats "bwato" to engine-powered boats, enabling them to fish further offshore. Some fishers also attributed the increase in fish catch to the increased number of incomes gained from sales which is the case now because of scarcity of those species. Other factors, such as alterations in net material and weather conditions, were also mentioned. The study noted that fishers that highlighted an increase in fish catch only made emphasis on changes within the past five years, with an emphasis of influx catches within 2024 and 2023 due to the presence of Chambo in fish catches and Usipa catches.

4.3.1 Empirical Evidence of Fish catch and Trends

The Karonga fish catch data collected from the fisheries department showed significant fluctuations in fish catches over the years, with periods of both high and low catches. The overall fish catch data trend showed a decrease in the total fish catch in the current years compared to the 1990s which coincided with fishing communities' perception.

The study further conducted a Pearson correlation analysis using annual time series of meteorological data and fish catch to show the relationships between rainfall, temperature and catch (Figure 7). The results showed a weak negative relationship between temperature and catch ($r = -0.335$, $p<0.005$, $n=68$) and a strong negative relationship between rainfall and temperature ($r = -0.655$, $p<0.000$, $n=68$). The amount of catch likely decreases as temperature increases and the

amount of rainfall decreases as temperature increases. However, the study showed a weak positive relationship between rainfall and catch (r=0.327, p<0.006, n=68). The amount of fish catch increases as rainfall increases.

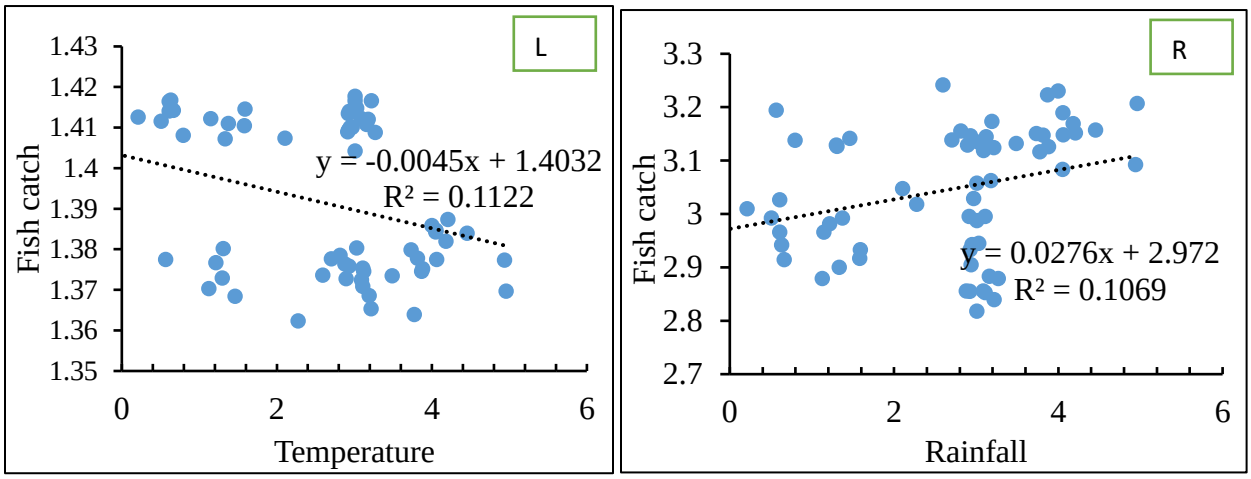

Figure 8: Relationship of Temperature and Fish Catch (L) and relationship of Rainfall and Fish Catch (R) (Source: AQUASTAT and Fisheries department)

4.3.2 Perceived impacts of Climate change to the Fishery resource and Fisheries

Most respondents (95%) acknowledged awareness of climate change impacts on the fisheries ecosystem. Among them, 86% noted that climate change alters fish distribution, with some fish moving to deeper waters to escape extreme hot temperatures and seek food. "*Previously, we could encounter fish when swimming and fish was caught using baskets and wrappers (nsalu), but now even fishers using bwato boats suffer as fish moved offshore*," explained a fisher at Chipamira beach. Changes in fish species composition were also reported, with species like *Opsaridium microlepis, Oreochromis spp. (Oreochromis karongae), Copadichromis spp., Petrotilapia spp.* being less abundant than before.

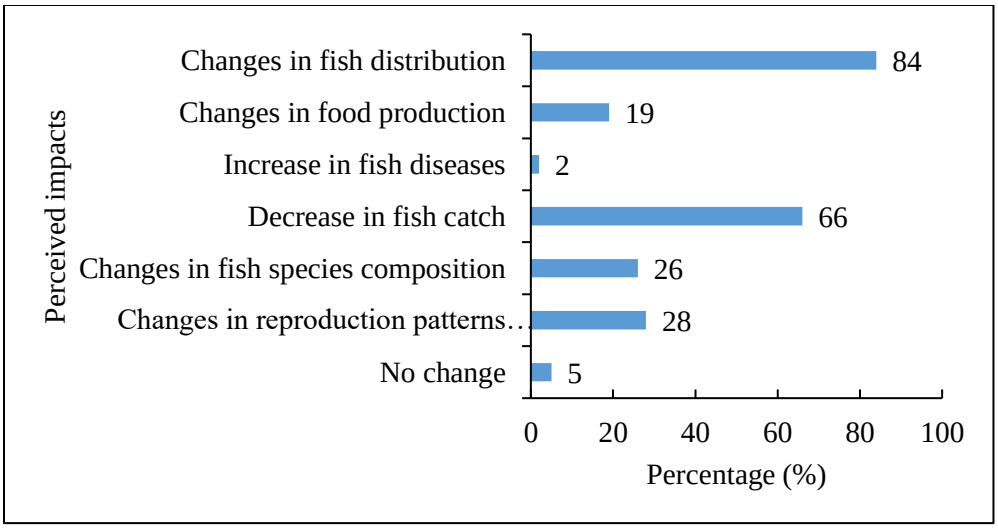

Figure 9: Karonga fishing communities perceived impacts of climate change on the fishery resource

During a focus group discussion at Chipamira community, a member highlighted that "*extreme hot temperatures and late rains disrupt the reproduction patterns of species like Catfish and migration patterns of fish that travel to rivers to breed*". Another fisher highlighted that "*Drought and delayed rains reduce fish catch because fish die from a lack of food since, rain and runoff provide essential nutrients that support fish in the lake*". Strong winds and heavy rains were also cited as disrupting fish availability, particularly Usipa. "*Strong winds and heavy rains in August have led to Usipa scarcity, whereas in previous years, this month brought abundant catches*," explained one fisher. Climate change was also reported to have influenced the reduction in Usipa sizes compared to the 1990s and increasing blood content in Usipa.

Additionally, 82% of respondents reported currently experiencing the impacts of climate change on fisheries resources, whereas 13% anticipated these impacts within 1-50 years and 5% did not foresee climate change affecting fisheries. The targeted fish species of fishers varied depending on the season, including *Engraulicypris sardella, Oreochromis spp, Copadichromis spp, Rhamphochromis spp, Clarias gariepinus, Synodontis njassae, Diplotaxodon spp, Lenthrinops*

spp, Bagrus meriodionalis. However, 43% of respondents have altered their targeted fish species over the last three decades due to scarcity of species such as *Opsaridium microcephalus, Bathyclarias spp, Oreochromis karongae and Copadichromis spp*, which were previously abundant.

All fishers recognized the adverse effects of extreme weather events like strong winds, currents, floods, and heavy rainfall on fisheries and their activities. These events hinder fishing efforts (70%), disrupt income streams (71%), and damage fishing vessels (43%) and gear (40%). Tragically, strong winds have even resulted in fatalities (31%) among fishers on the lake. Extreme weather events cause destruction to landing sites (22%), fish kills (7%), and diminished catches, prompting fishers to venture farther offshore (16%) in search of fish, thereby increasing risks to their safety and incurring additional costs for fuel.

4.3.3 Impacts of low fish catches on the livelihood of fishing households

All respondents highlighted that low fish catches significantly impact their livelihoods. Even those reporting increased catches over the past 30 years cited challenges due to the unpredictability of fishing; some day's catch is plenty while others are not. This inconsistency leads to reduced income (89%), limiting access to household food (61%), and increasing the risk of malnutrition or undernutrition (7%) due to a lack of protein from fish. As a result, fishermen often migrate (41%) to other fishing beaches or districts in search of better catches, while some (17%) exit the fishery altogether. Additionally, the reduced income affects children's education opportunities and the ability to undertake developmental activities such as land ownership, home construction, vehicle purchase, and investments.

The majority (62%) of the respondents reported that the money they make from fishing decreased over the past five years due to fewer fish catches, which influences the number of shares among

the crew members to be fewer. This has resulted in fishers experiencing periods where their households have no or little food (63%) and are only able to eat twice a day (54%). Additionally, fishers (62%) reported that their inability to provide basic needs for their household is attributed to low fish catch, low sales and many people in the house. In contrast, 38% of fishers reported an increase in the money made from fishing over the past five years. This was attributed to the scarcity of fish, pushing prices up. However, they noted that because of the devaluation of kwacha, their income is still insufficient for their needs.

"*In the past, there were more fish (by volume per catch) but less money, but that money had more value; however, nowadays, we catch fewer fish but make more money due to demand*" explained one of the fishers in a focus group discussion held at Ngara community "*although the money made from fishing is more now than before, we still face challenges providing for our families because now things are more expensive than before"*, he added.

Fishers also reported the closed season period as another barrier to their livelihood because they could not make an income. Therefore, fishers develop other income sources, such as farming, off-farm labour, small-scale business, and boat repair for sustenance when the lake is declared closed. However, 55% of the respondents reported still going to fish during closed season as fishing is their main source of income. Some fishers reported changing the targeted species and gear used during this time however, others did not.

"*I still go fishing when the lake is closed because I need to make money, or people at my house will starve, especially my children. The lake is God's creation, and so is fish therefore, no one can tell us to stop fishing,*" explained one of the fishers. "*God can never allow fish to finish in the lake, so there is no need for closed season and banning the use of certain gears as it exposes us to poverty"*, he added.

This aligns with a key informant's observation that many fishers lack regard for the sustainable use of fishery resources. He emphasized the importance of reducing fishing pressure, establishing and managing sanctuaries to ensure fish reproduction, and encouraging beach village committees (BVC) to enforce laws to preserve the lake's fish for future generations. "*We are working with BVCs to encourage fishers to reduce fishing pressure and focus on other sustainable income-generating activities. Low fish catches have led to more violations of fisheries laws, increased theft, and land disputes as more people turn to farming*".

4.4 Fishing communities coping strategies

The majority (96.5%) of the respondents had coping mechanisms in the face of low fish catches, whereas 3% continued to depend solely on fishing, and 0.5% reported exiting the fishery. Respondents had diversified income sources such as farming (68%), fish farming (6%), off-farm labour (22%), small-scale businesses (54%), livestock farming (31%) and boat repair (1%). Increased time spent on fishing grounds (3%), fishing using prohibited gear (10%), fishing during closed season (22%), migration (33%), and changes in targeted species (18%) were some of the reactive changes made by fishers in response to low fish catches to generate income.

One respondent ceased fishing due to declining fish catches, stating, "*The expenses for fuel and other fishing costs now outweigh the profits I used to earn in previous years because fish stocks in the lake have decreased. With more fishermen, I found pursuing alternative income-generating activities on land more profitable."*

Fishermen attribute their lack of coping strategies to poverty. However, this is contradicted by certain common behavioral patterns among fishermen, such as engaging in multiple sexual relationships and alcohol consumption. "*Fishing can yield considerable income, but this diminishes when divided among the boat owner and crew members. Many fishermen stop at pubs*

or bars along the beaches before returning home, reducing their earnings. Additionally, fishermen often engage in relationships with multiple women and father numerous children, straining their finances," reported a key informant in Karonga. He also noted, *"Migratory fishermen frequently engage with prostitutes at the beaches they visit, further depleting their investment funds and risking their health.*"

4.4.1 Factors affecting fishing communities' ability to cope to Climatic impacts on fish catches

A logistic regression was then conducted to ascertain the effects of socioeconomic factors and incidence of extreme weather events on the probability that the fishers will cope with fish catch fluctuations. The estimated coefficients of the logistic regression are presented in Table 3 along with the levels of significance, standard errors and odds ratios.

Table 3: Binary logistic regression analysis results of factors influencing fishing communities (n = 311) ability to cope with perceived fish catch changes.

Explanatory Variables	Coefficients	Standard error	Sig.	Exp (B) (odds ratio)
What is your highest level of education	1.377	1.300	.289	3.965
Age of Respondent	.130	.932	.889	1.139
How many years have you stayed in the area	-1.301	.965	.178	.272
How long have you been fishing	.531	.806	.510	1.700
Gender of Respondent	-16.892	6495.200	.998	.000
Marital Status	1.798	1.065	.091	6.037
Do you have access to weather forecast information from the meteorological department	-.975	.946	.303	.377
Do you have access to extension workers	1.542	.731	.035*	4.676
What is your position in the family	-19.641	21707.459	.999	.000
Has there been any changes in the amount of fish catches over the past two decades	-18.216	14464.457	.999	.000
Are you aware of climate change and variability	1.304	1.465	.373	3.685
Constant	-56.954	11306.844	.996	.000

Source: Fishers' perceptions survey data, 2024. Notes: n = 311. For binary variables (coping), no = 0 and yes = 1. *indicate significant coefficients at significance levels of 0.05.

The model showed that having access to extension workers significantly increased the likelihood of fishers having coping mechanisms. Fishers with access to extension workers were 5 times more likely to adopt coping mechanism compared to those without access.

CHAPTER FIVE: DISCUSSION

5.1 Fishing communities' perception of climate factors (temperature, rainfall, lake water level, wind)

The present study attests that residents in Karonga district (Chiwondo, Chipamira and Ngara communities) perceive climate changes observed through shifts in temperature and rainfall trends over the past 3 decades, rising lake water levels, changes in weather patterns and increased occurrence of floods and droughts (Table 2). Fishers recalled experiencing extremely hot temperatures, late rains, and weather extremes, attributing these to climate change. Their perceptions were shaped by access to weather information, extension services, traditional knowledge, and local experience. These findings align with studies by Howe and Leiserowitz (2013), Limuwa *et al.* (2018), Musinguzi *et al.* (2016), Muringai *et al*. (2022), Ha and Thang (2017) and Mafongoya *et al.* (2019), which reported an increase in local communities' awareness of climate change and variability. This awareness is a promising indicator for climate intervention, as understanding climate impacts is a critical first step in adopting adaptation strategies therefore, fishing communities in Karonga are more likely to develop coping mechanisms. Previous research also highlights that perceiving local climatic changes is the first step in the adaptation process to mitigate the effects of climate variability (Leiserowitz, 2006; Deressa *et al*., 2011).

This study revealed that perception is partly subjective. Among the respondents, 90% reported rising temperatures, while only 6% noted a decrease. For rainfall, 77% perceived a decline, whereas 20% observed an increase (Table 2). This was the case because some fishers based their perceptions on short-term observations rather than the full 30-year period and relied on traditional methods to predict climatic changes instead of scientific data, making it challenging for them to

make informed decisions on factors affecting their livelihood. These findings align with Simelton *et al.* (2013) and Nursey-Bray *et al.* (2012), who both noted that individuals in the same region may perceive climate differently despite similar experiences, as such discrepancies may stem from the ease of accurately describing changes over shorter periods compared to longer periods (Orlove and Roncoli, 2006). To address the disparities in fishers' perceptions of climate change, this study used time series meteorological data to validate the community's views, as recommended by Broadhead and Howard (2011), Limuwa *et al. (*2018) and Mafongoya *et al.* (2019). This approach is essential because small-scale fishers and farmers often base perceptions on local conditions rather than broader climate trends (Bryant *et al.*, 2000; Bewket, 2012; Esham and Garforth, 2013; Kassie *et al.*, 2013; Roco *et al.*, 2015; Arunrat *et al.*, 2017). The results underscore the importance of ensuring climate change information is available to all community members, as misconceptions can hinder adaptation efforts. Misconceptions are often rooted in limited observations or traditional knowledge, leaving communities vulnerable to adverse climatic impacts. Empowering fishers with reliable data can strengthen decision-making and build long-term resilience.

The trend analysis of temperature aligned with the fishing community's perceptions, showing a slight increase in the average mean temperatures within the district (Figure 5). This was further corroborated by the Karonga Climate Profile conducted by the University of Cape Town (2017), which reported an increase in average temperatures of 0.1°C and 0.2°C over time. The profile also highlighted the difficulty of distinguishing between trends and variability over longer timescales as experienced by the study. The study revealed discrepancies between the fishers' perceptions of rainfall and the district's meteorological data, as the trend indicated an increase in the average annual rainfall in the district (Figure 3). These findings are consistent with other scholars where

the local knowledge of the fishers could not match the conventional scientific knowledge on the changes in their ecosystem (Limuwa *et al.*, 2018). These differences may be due to the tendency to describe changes more accurately over shorter periods rather than longer ones, and agriculture challenges could drive the perception. The meteorological data confirmed that Karonga District's climate is undergoing significant changes, posing serious threats to communities whose livelihoods depend on natural resources. Despite this, there is a limited understanding of the potential impacts on critical sectors such as agriculture and fisheries, heightening the vulnerability of these communities. These climatic changes could profoundly affect resource availability, sustainability, and overall community resilience, underscoring the urgent need for targeted interventions and increased awareness of climate-related risks.

The study found that respondents defined climate change differently based on their duration of residence, age, and access to weather forecasts. Notably, 82% of fishers accessed weather forecasts through various channels, enhancing their understanding of climate change. This supports research indicating that perceptions are shaped by factors such as culture, education, gender, age, resources, cognitive reasoning, and institutions (Akerlof *et al.*, 2013; Shi *et al.*, 2016). Previous studies also show that age and fishing experience increases the likelihood of recalling significant climate events (Marx *et al.*, 2007). Most respondents (90%) reported experiencing extreme weather events such as strong winds, floods, late rains, dry spells, and droughts, consistent with (Pasquini, 2020), who noted that the people of Karonga are aware of changes in climatic parameters, such as rising water levels, temperature fluctuations, rainfall variations, and increased frequency of floods and droughts. Additionally, Manda (2014) identified Karonga as highly vulnerable to extreme events, including floods and droughts emphasizing the urgent need for interventions to support

communities heavily dependent on natural resources for subsistence such as fisheries. Respondents' perceptions of extreme weather events likely stem from their exposure and experience hence, it is important to take advantage of these factors to increase climate change awareness among communities (Dessai and Sims, 2010; Le Dang *et al.*, 2014).

Most (82%) of respondents reported currently experiencing the impacts of climate change on fisheries resources, while 13% anticipated these impacts within the next 1 to 50 years, and 5% did not expect climate change to affect fisheries at all. The study indicated that some fishers view the impacts of climate change as a future concern which impacts their adaptability to climate change. This aligns with the findings of Reynolds *et al*. (2010), which highlighted that many individuals believe the threats associated with climate change are unpredictable, distant, and primarily a future concern. These perceptions often stem from a limited understanding of the complex physical processes underlying climate change. As a result, people may feel confused about how their actions connect to broader climate-related issues leading to their failure to conserve the environment and adapt (Maslin and Austin, 2012). Fishers' ability to perceive climate changes and their impacts on fisheries resources directly influences communities' coping strategies therefore, viewing climate impacts as distant or unlikely can discourage the pursuit of alternative livelihoods, limiting communities' preparedness and resilience to climate change impacts.

5.2 The perceived climate change impacts on fisheries and fish catches

This study found that fishers in Karonga district could associate changes in climatic trends and extreme weather events with several effects on fish production, fish catch, and the livelihoods of fishery-dependent households (Figure 9). Fishers observed that extreme heat drives some fish

species further offshore in search of cooler waters, altering their distribution. They also noted that rising temperatures reduce food availability near the shore, affecting fish populations. Additionally, extreme weather events such as floods and erratic rainfall were reported to decrease fish catch, while changes in rainfall patterns were linked to challenges in catfish reproduction. These perceptions are shaped by fishers' experiences and traditional knowledge of how targeted species have changed over time in Lake Malawi. Their observations of shifting fish migration, breeding seasons, and environmental cues offer valuable insights that can complement scientific research on the impacts of climate change on fisheries.

Numerous studies have found that climate change affects fisheries, for instance; changes in temperature and rainfall impact fish since fish are poikilothermic creatures (Cong and Brady, 2012; Asiedu *et al.,* 2017). Changes in climatic parameters disrupt fish habitats, fish physiological functioning, spawning and reproduction (Arantes *et al.,* 2013; Wang *et al.,* 2016; Whitney *et al.,* 2016). When fishing communities are aware of these dynamics, they can become critical agents in the collective effort to safeguard aquatic ecosystems and secure their livelihoods against the growing threat of climate change. Perceiving climate change impacts on fisheries fosters a sense of ownership and responsibility for addressing environmental challenges among communities and empowers them to advocate for and implement adaptive strategies tailored to their local contexts (Limuwa *et al.*, 2018). The study highlights the importance of integrating traditional knowledge with scientific research as by bridging this knowledge gap fishing community can develop more effective context specific adaptation strategies ensuring long term sustainability of fish stocks and livelihoods.

A Pearson correlation analysis was conducted using annual time series data to validate fishers' perceptions of the relationship between temperature, rainfall, and fish catch. The analysis revealed a weak negative association between temperature and fish catch in Lake Malawi (Figure 7). This finding supports the suggestions of Ndebele-Murisa *et al.* (2013) that rising temperatures have led to a decline in primary production in Sub-Saharan lakes, including Lake Malawi, which negatively affects fish stocks and the livelihoods dependent on them. Additionally, research has shown that higher temperatures lead to lower dissolved oxygen levels, which can diminish fish populations and growth in lakes, further impacting fish stock and catch (Ndebele-Murisa *et al.*, 2014; Abdel-Tawwab *et al.*, 2015; Potts *et al.*, 2015). The study also identified a weak positive association between rainfall and fish catch (Figure 8), suggesting that an increase in rainfall is likely to lead to an increase in fish catch. This agrees with Bootsma and Hecky (1999), who noted that high rainfall introduces nutrient fluxes into lakes via rivers, thereby enhancing nutrient availability and promoting fish production. Barange *et al.* (2018) argue that decreasing rainfall and reduced runoff will lead to diminished food availability for fish, ultimately lowering fish stocks.

Changes in rainfall and temperature significantly affect the productivity of aquatic ecosystems and fish yield (Behrenfeld *et al.*, 2006; Cheung *et al.*, 2009), which in turn impacts fishers' livelihoods. The weak associations between temperature, rainfall, and fish catch indicate that low fish catches result from multiple factors, not solely climate change. Both climatic and non-climatic factors, such as overfishing and poor fishing practices, play a role. The results also suggest that climate effects on fish stocks occur only when critical thresholds are exceeded, with species-specific tolerance influencing the impact.

The study also utilized fish catch data from the past three decades to validate fishers' perceptions of decreasing fish catches over the years. The data indicated a decline in fish caught from 1992 to 2023. These findings are consistent with multiple studies that have reported decreased fish catch in Lake Malawi (FAO, 1993; GOM, 2000; Darwall and Allison, 2002; FAO, 2012). For instance, the annual economic report (2024) noted a decrease in per capita fish supply from 12.6 kg in 2018 to 9.65kg per person per year in 2023. Banda *et al*. (2005) also noted a significant drop in total annual fish catch; in early 1982, Chambo constituted 49% of the total annual fish landings in Lake Malawi, but by 1999, this figure had plummeted to just 7%. Additionally, Jamu *et al.* (2011) reported that Chambo stocks began to decline in the early 1990s, ultimately failing to support small-scale fishers in southern Lake Malawi, leading to economic losses for both the fisheries sector and the national economy. The decline in Chambo and other high-value species has resulted in a shift in targeted species, with fishers now focusing on smaller, less economically valuable fish such as *Engraulicypris sardella* signaling ecosystem changes. The 2024 Annual Economic Report indicated that *Engraulicypris sardella* accounted for 45% of the total fish catch in 2023, surpassing major commercial species such as *Oreochromis spp.*, *Opsaridium microlepis*, and *Rhamphochromis spp.*

Fishers attributed the decrease in fish catches to various factors, including the use of illegal gear, population growth, overfishing, weak governance and environmental changes such as climate. The study highlighted population growth, overfishing and poor fishing practices as the major causes of low fish catches as compared to climatic factors which agrees with Limuwa *et al.* (2018), who found that fishers in Lake Malawi believe low fish catches are due to an increasing fisher population, heightening competition for dwindling stocks. Studies indicate that the use of small

mesh-sized nets, weak law enforcement, and the need to survive are driving forces behind the depletion of fishery resources in Lake Malawi (Turner, 1977; Weyl *et al*., 2004; Allan *et al.*, 2005; Tweddle *et al.*, 2015). The evidence of illegal fishing gears, fishers fishing in restricted locations and during closed season were prevalent hence attributing changes in fish catch entirely to changes in climate could not be warranted even though climate has been known to affect the fisheries ecosystem. These findings agree with Cheung *et al.* (2009) who found it difficult to conclude whether climate was impacting the fishery resource. The fluctuation of Malawi's fisheries resources is attributed to several factors and it greatly affects fishers' livelihoods (Weyl *et al*., 2010) and forces some fishers to engage in unsustainable practices (Banda *et al*., 2005). The study indicates that efforts to address declining fish catches should prioritize strengthening fisheries management and enforcement and promoting sustainable fishing practices alongside climate adaptation strategies.

Fishers reported experiencing erratic rainfall, extreme heat, droughts, floods, and strong winds as extreme weather events that impacted their fish catches. Floods and strong winds were noted to damage fishing gear and boats, disrupt fishing schedules, and sometimes result in injuries or fatalities. These findings align with those of Musinguzi *et al.* (2016) and (Westlund, 2007), who documented similar impacts, such as floods damaging fishing boats and gear, damaging landing sites, reducing fishing days in Uganda, and causing loss of life in Indonesia. Additionally, strong winds were reported to capsize boats, leading to drownings and injuries among fishers in Lake Kariba (Mafongoya *et al.*, 2019). Despite receiving warnings of unfavorable weather, many fishers in Karonga continue fishing due to their lack of trust in the information and heavy reliance on fishing as a primary income source. This exposes them to significant risks, including life-

threatening situations. The study highlights the urgent need for improved weather forecasting systems, tailored communication strategies, and community engagement to build trust in climate and weather information since effective dissemination of accurate, timely, and actionable weather forecasts can help fishers plan their activities more safely, limit their skeptism and reduce exposure to hazardous conditions.

Fishers also reported changes in their livelihood assets and income levels, the inability to send children to school, and challenges in providing basic household needs because of low fish catches. Research indicates that climate change impacts on livelihoods are reflected in livelihood assets, activities, and outcomes (Jallow *et al.*, 1999; Elasha *et al.*, 2005). Allison *et al.* (2002) emphasized that fluctuations in fisheries lead to significant seasonal variations in families' reliance on fishing, increasing their risk of poverty and food insecurity. For example, small-scale fishers in Lake Kariba noted that declining fish catches negatively affect their livelihoods by reducing their income and heightening their vulnerability to poverty (Ndhlovu *et al.*, 2017; Muringai *et al.*, 2020). The decline in fish catch affects not only immediate income but also the long-term well-being of households. The inability to afford education for children perpetuates cycles of poverty, as education is a critical pathway to diversified income opportunities and socio-economic mobility. Challenges in meeting basic needs further exacerbate vulnerabilities, leaving households with fewer resources to adapt to climate change impacts. These findings underscore the need for comprehensive strategies to enhance resilience in fishing communities by supporting income diversification, such as introducing aquaculture, value-added fish processing, or non-fishing-related livelihoods which can reduce dependency on declining fish stocks.

5.3 Coping strategies of fishers in response to low fish catches and their determinant factors

Fishers in northern Lake Malawi district of Karonga interpret and respond to climate change impacts in various ways. Their perception is influenced by how these climatic changes affect fishery resources and their livelihoods, which can aid their adaptation. This study found that majority of fishers demonstrated an ability to adapt to declining fish abundance by diversifying their income sources. They engaged in activities such as farming, selling fish, fish farming, off-farm labor, small-scale businesses, livestock farming, village bank and boat repairs. However, some fishers engaged in reactive mechanisms such as spending more time fishing, migrating to new fishing grounds, changing fishing gear, fishing during closed seasons, and altering target species. Research has confirmed that small-scale fishers in Malawi employ multiple coping strategies to address low fish catches by diversifying their income-generating activities (Allison and Mvula, 2002; Mvula, 2002; Hatlebakk, 2012; Adeleke and Wolff, 2016). The study reported lack of funds and access to trainings as some of the causes restricting fisher's ability to venture into alternative livelihoods hence highlighting gaps that can be addressed by government and stakeholders in enhancing adaptive strategies. By supporting and scaling up these coping strategies, the fisheries sector can address the challenges of climate change impacts and resource management, fostering a more sustainable and resilient future for the industry and its stakeholders.

Most fishers engaged in various alternative livelihood activities, reducing their reliance on fishing as their sole source of income and thereby mitigating the impacts of low fish catches. Research indicates that small-scale fishers in Lake Malawi, Lake Kariba, and Lake Wamala have diversified their income sources to include sustainable non-fishery activities such as farming and business (Musinguzi *et al.*, 2016; Limuwa *et al.*, 2018; Muringai *et al.*, 2022). Brugère *et al*. (2008) found

that diversifying into non-fishery activities could be the most effective adaptation strategy for fishers, providing support during periods of low catches. Households with a wide range of alternative livelihoods enjoy greater flexibility, spreading risks and reducing vulnerability to the impacts of fishery decline (Allison *et al.*, 2002; Waiyaki *et al.*, 2012; Savo *et al.*, 2017; Akaba and Akuamoah-Boateng, 2018; Cinner *et al.*, 2018). This diversification is significant for the fisheries sector because it reduces pressure on fish stocks by encouraging sustainable use of resources. By supporting and facilitating fishers' transition into alternative livelihoods, the fisheries sector can promote resource recovery and conservation while ensuring that communities maintain economic stability.

The study also highlighted that some coping mechanisms adopted by fishers, such as increasing fishing time, modifying gear, changing target species, migrating, fishing during closed seasons, and fishing in protected areas, are unsustainable and mainly beneficial in the short term. Mvula (2002) and Coulthard (2009) reported that these adjustments are not permanent but rather diversification strategies in response to low fish catches. For example, fishers in Uganda and Kenya modified their gear, spent more time fishing, and migrated to other areas to cope with declining catches (Belhabib *et al.*, 2016; Musinguzi *et al.*, 2016; Selgrath *et al.*, 2018). Changing fishing gear and increasing fishing time are widely used strategies by fishers to deal with dwindling fish stocks. However, the study reported that fishers were changing from legal fishing gear to using monofilament nets and mosquito nets, which are not selective and catch juvenile fish. The findings highlight gaps and weaknesses in the enforcement on illegal gear usage ban due to the prevalence of illegal gears within the district. This aligns with findings by Makwinja *et al.* (2021) and McLean *et al.* (2016), who reported that using illegal gear as a coping mechanism may temporarily increase

catch but is not sustainable long-term, jeopardizing future generations' livelihoods and food security. To promote sustainable coping mechanisms, the Fisheries departments can develop targeted policies and programs by addressing the root causes of unsustainable strategies, such as inadequate income, weak enforcement of fishing regulations, and lack of alternative livelihoods.

Short-term coping mechanisms, such as increasing fishing efforts by using more gears and boats and switching to small-mesh nets, contribute to the overexploitation of fish stocks and result in the capture of juvenile fish. This aligns with Pedroza-Gutiérrez and López-Rocha (2016), who noted that increasing fishing efforts and changing gear types are primary drivers of overfishing, leading to a decline in total fish production over time. This decline threatens the capacity of fish resources to sustain fishers' livelihoods and food security (Black *et al.*, 2011; Warner and Afifi, 2014; Nyamweya *et al.*, 2020). The study also cited a change in the target species as a coping mechanism some of the fishers adopted. Fishers reported change from species such as *Oreochromis spp., Rhamphochromis spp.,* and *Copadichromis spp.,* which were abundant in the past years but are now scarce, to species that are available now, such as *Engraulicypris sardella*. This is similar to findings by Karenge and Kolding (1995) and Musinguzi *et al*. (2016) that fishers in Kariba and Wamala were able to perceive changes in fish composition hence, fishers changed to target species that were abundant in that period of time for food and income. Understanding fishers' adaptability in targeting different species provides valuable insights for designing species-specific management plans and conservation strategies. These findings underscore the need for strengthening regulation and enforcement of fishing practices, promoting the use of sustainable gear, and supporting alternative livelihoods to reduce pressure on fish stocks while ensuring the long-term resilience of fishing communities.

The study found that the decline in fish catches had varying impacts on fisher households, with some fishers reporting increased income due to the scarcity of fish, while others faced reduced sales because they were unable to catch enough fish. Malone and Engle (2011) observed that climatic events and extremes can have varying socio-economic impacts within the same community, either increasing or decreasing people's vulnerability, which affects their ability to adapt. The study identified that having access to extension services influences fishers' adoption of adaptation strategies. Access to extension services is expected to increase fishers' probability of coping with climate change impacts by 5-fold. Several studies have found similar findings and report that training programs help farmers to identify climate change events, thus preparing them to cope better (Kandlikar and Risbey, 2000; Jones, 2003; Baethgen *et al*., 2004). However, even though the logistic regression model was appropriately specified, important variables like age, education, access to information, and income recognized for their impact on coping behavior were not statistically significant ($p > 0.05$). Although variables like age, education, access to information, and income were not statistically significant in this study, the recognition of these factors in previous research emphasizes the need for comprehensive support systems that account for the broader socio-economic context in which fishers operate (Nhemachena and Hassan, 2007; Bryan *et al.*, 2009; Jiri *et al*., 2015; Limuwa *et al.*, 2018). The study underscores the importance of providing targeted extension services and training programs to enhance fishers' adaptive capacity, enabling them to better cope with the impacts of climate change in order to enhance resilience, and ensure the long-term viability of their livelihoods.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Fishers reported that they have observed alterations in weather patterns, including decreased rainfall, intensified temperature, rising water levels in the lake, and increased frequency of extreme weather events such as floods, droughts, and strong Mwera winds over the past 30 years. Fishing community's perceptions of heightened extreme weather events were supported by existing literature on the Karonga climate profile. This perception is crucial because it shapes communities' response strategies and coping mechanisms, as their ability to identify and acknowledge these changes empowers fishers to adapt and innovate. However, the study also noted disparities in how fishers perceive climate changes within the same localities, which impacts how fishers adapt to climate change. Access to weather information was an influencing factor in the communities' awareness of climate change, and this was achieved through listening to radios, attending church services, using phones, and being visited by extension workers. Understanding how fishers observe and interpret climate changes informs targeted adaptation strategies and highlights the critical need to bridge gaps in access to weather information.

Fishers acknowledged that climate change and extreme weather events adversely impact fish production, significantly affecting fish catch. The observed climate changes were perceived to have had a detrimental effect on the fisheries sector, leading to declining fish stocks, habitat loss, alterations in fish physiology and reproduction, reduced catches, diminished profits, food insecurity, and increased risks to fisher safety. Incidents of strong winds and floods hindered fishers fishing efforts, resulting in fewer fishing days and lower income, while strong winds posed additional threats to their lives. The study further explored the relationship between rainfall,

temperature, and fish catch. It found that rising temperatures were associated with decreased fish catches, while increased rainfall was likely to enhance the probability of catching more fish. However, the study did not fully establish whether the observed low fish catches were directly attributable to climate change, indicating a need for further modeling of climate trends (rainfall, temperature, water level) and fish catch data to clarify this relationship. This is important as it shapes the country's current and future views on climate change impacts and the threats it possesses to fishing communities' livelihoods in order to generate preventive measures and adaptive strategies.

The perceived decline in fish catches by fishers corresponded with a documented decrease in the district's total fish catch over the past three decades. This decline has been attributed to factors such as population growth, overfishing, the use of illegal gear, weak law enforcement, and climate change. Additionally, low employment rates and challenges in farming led to an influx of fishers in the district, exacerbating overfishing. The study also highlighted a rise in the use of illegal, unreported, and unregulated fishing methods, such as monofilament and mosquito nets. As a result, the decline in fish catch has presented numerous livelihood challenges for fishers, including low income, reduced food access, limited investment opportunities, difficulties in funding children's education, and an inability to meet basic household needs. The study observed the critical impact of declining fish stocks on the socioeconomic stability of fishing communities, highlighting the interconnected nature of environmental and livelihood challenges within the district. The challenges causing the decline of fish stocks are multifaceted, underscoring the need for strengthened enforcement of fishing regulations, alternative livelihood options, and community-based resource management initiatives.

The study indicated that fishers in Karonga district employ various livelihood strategies to adapt to changing fisheries resources caused by climate change. These strategies included pursuing alternative livelihoods, migration, casual labor, altering fishing gear, increasing fishing hours and effort, and targeting new species. However, some of the strategies may only provide short-term benefits, potentially harming the fishery and promoting unsustainable practices that threaten the resilience of the ecosystem hence, there's a need for government assistance when it comes to developing adaptive strategies. Other researchers emphasize the importance of regulating fishers through measures such as closed seasons and promoting sustainable fishing practices which requires the Malawi Government to implement robust policies to control input targets for fisheries.

Fishers noted that lack of funds, lack of access to loans, lack of alternative livelihood, and lack of resources were factors hindering their adaptation. The choice of adaptation strategies among fishers was primarily influenced by socio-economic factors such as access to extension workers hence, there's a need to consider these factors when formulating climate adaptation policies and providing government aid to these communities. Access to trained extension workers ensures that communities are receiving tailored support that addresses their specific needs and challenges. This is crucial as it forms a link between fishers and scientific research, ensuring that local practices are informed by the latest environmental data hence, there's a need to capitalize on these factors in order to increase fisher adaptation. A study of this nature could also be used to inform the Karonga district council socio-economic profile on management of natural resource-based livelihoods when claims related to climate change are perceived to affect livelihoods.

6.2 Recommendations

The findings of this study underscore the urgent need for comprehensive support for fishers as they navigate the impacts of climate change. By strengthening access to extension services, strengthening fisheries enforcement, formulating fisheries climate change strategies to guide climate financing in the fisheries sector, promoting sustainable adaptive strategies by infusion of local and modern knowledge to create a clear understanding on adaptation and mitigation, and strengthening decentralization of fisheries management by formulating synergies in implementation of adaptation measures with other institution, to enhance the resilience of fishing communities. These collaborative efforts will empower fishers to adapt to environmental changes, ensuring the sustainability of their livelihoods and the health of Lake Malawi's ecosystems.

Based on the study's findings, there is a pressing need to enhance public awareness of climate change to address the disparities in how fishers perceive the causes and effects of climate change on fisheries resources. Fishers make decisions based on traditional knowledge and not scientific data hence there's need for governments and stakeholders to allocate more resources to extension services focused on educating local communities on sustainable practices, risk assessment, and climate adaptation strategies. This can be achieved by strengthening access to extension workers and diversifying means to spread climate change information to local communities. The study recommends a unified front when it comes to community outreach and dissemination of climate change information by different sectors (an ecosystem-based approach). This can be achieved through conducting workshops or seminars and engaging media houses on closed season warnings, climate-altering activities such deforestation, alternative climate-smart methodologies/activities, and sustainable resource management.

The study identified the rampant usage of illegal, unreported and unregistered gears in the district as a major factor in declining fish stocks as compared to climatic impacts, calling for stronger fisheries enforcement. The study recommends that the government allocate more resources to the Department of Fisheries to ensure frequent patrols are conducted and that there's constant monitoring by fisheries officers at landing sites. Fishers reported the lack of a net manufacturing company in the country as one of the factors leading to rampant usage of monofilament nets hence, the study recommends the government or private sector to fill this gap. This study calls for strengthening Local Fisheries Management Associations (LFMAs) through training, coaching, and funding. Additionally, the study advocates for improved collaboration among community committees, including Village Civil Protection, Area Development Committees (ADCs), Village Development Committees (VDCs), and Beach Village Committees, to promote an ecosystem-based management approach.

This study strongly recommends that policymakers integrate local insights with scientific data to gain a comprehensive understanding of the vulnerabilities faced by fishing communities. By considering fishermen's perspectives on climate change and adaptation strategies, more effective fisheries policies can be developed. Furthermore, policymakers and advocates for poverty reduction should prioritize targeted support for fishing communities, as they are among the most vulnerable to the impacts of climate change. The study also calls for the formulation of fisheries climate change strategies to guide climate financing in the fisheries sector, ensuring that the vulnerabilities of fishing communities are documented and addressed through interventions from the government and stakeholders, including financial assistance, access to resources and loans, and capacity-building initiatives to help these communities enhance their resilience.

Lastly the study identified the need to promote proactive sustainable adaptive mechanisms. This can be achieved by formation of synergies in implementing adaptation strategies with other institutions. Fishers highlighted wanting to venture into other livelihood activities such as farming, livestock rearing and business however, they indicated lack of knowledge and resources as a primary factor hindering them. Hence the study suggests collaborative approaches when it comes to provision of trainings on alternative livelihood sources and resources to enable communities to cope. Communities dependent on natural resources are all vulnerable to climate change therefore, government and stakeholders should prioritize fostering help to all communities when hit by extreme weather events without giving special consideration to one group than the other.

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APPENDICES

Appendix A: Ethical Clearance

MZUZU UNIVERSITY

DIRECTORATE OF RESEARCH

Mzuzu University
Private Bag 201
Luwinga
Mzuzu 2
MALAWI
TEL: 01 320 722
FAX: 01 320 648

MZUZU UNIVERSITY RESEARCH ETHICS COMMITTEE (MZUNIREC)

Ref No: MZUNIREC/DOR/23/119 **10/11/2023.**

Tikhala Chakalamba,
Mzuzu University,
P/Bag 201,
Luwinga,
Mzuzu 2.

chakalambat@yahoo.com

Dear Tikhala,

RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL REF NO: MZUNIREC/DOR/23/119: PERCEPTION OF FISHING COMMUNITIES ON CLIMATE CHANGE, FISH CATCH FLUCTUATIONS AND ADAPTIVE STRATEGIES: KARONGA DISTRICT.

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the Mzuzu University Research Ethics Committee (MZUNIREC) in a format that is available at the Secretariat. Once the study is finalised, you are required to furnish the Committee with a final report of the study. The Committee reserves the right to carry out compliance inspection of this

approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Committee Address:
Secretariat, Mzuzu University Research Ethics Committee, P/Bag 201, Luwinga, Mzuzu 2;
Email address: mzunirec@mzuni.ac.mw

Wishing you a successful implementation of your study.

Yours Sincerely,

Gift Mbwele

SENIOR RESEARCH ETHICS ADMINISTRATOR

For: CHAIRMAN OF MZUNIREC

Appendix B: Data collection tools

Name of Research Assistant: _____ Date of interview: _____

Fishing community: _____

GPS Coordinates_____

SECTION A
HOUSEHOLD DEMOGRAPHIC DATA

HR	Variable	Response (Use codes)
HR1	Name of respondent	
HR2	Gender of respondent	[1] = Male [2] = Female
HR3	Marital Status	[1] = Single, [2] = Married, [3] = Separated, [4] = Divorced, [5] = Widowed
HR4	Age of respondent	
HR5	What is your position in the family?	[1] = Parent, [2] = Child, [3] = Other Specify
HR6	Number of people in the household	
HR7	What is your highest level of education?	[1] = No formal education, [2] = Primary, [3] = Secondary, [4]= Higher education (college or university)
HR8	Apart from fishing, what other activities do you do to generate income?	[1] = Farming, [2] = Fish selling, [3] = Formal employment, [4] = off farm labor [5] = Small scale business, [6] = Other specify
HR9	How much is your annual income	
HR10	Which year did you start fishing?	
HR11	Are you a member of any conservation club	[1] = Yes, [2] = No

SECTION B

HOUSEHOLD SURVEY

Objective 1: FISHING COMMUNITIES PERCEPTION ON CLIMATE CHANGE

1. Are you aware of climate variability and changes such as?

[1] = Floods [2] = Drought [3] = Changes in temperature [4] = Changes in rainfall [5] = Changing weather pattern [6] = Changes in wind intensity [7] = Changes in water level [8] = Not aware [9] = I don't know

2. Have you observed any changes in temperature intensity that have occurred in your area over the past 3 decades such as?

[1] = Increase in temperature intensity [2] = Decrease in temperature intensity [3] = Hotter dry season [4] = Extreme hot days [5] = No change [6] = I don't know

3. Have you observed changes in rainfall intensity that have occurred in your area over the past 3 decades such as?

[1] = Increase in rainfall intensity [2] = Decrease in rainfall intensity [3] = Changes in the onset of the rainy season [4] = Heavier rains [5] = No change [6] = I don't know

4. How frequent does the community face incidences of droughts and floods within a year?

Droughts [1] = less than 3 [2] = 4-6 [3] = More than 6 incidences [4] = Never witnessed

Floods [1] = Less than 3 [2] = 4-6 [3] = More than 6 incidences [4] = Never witnessed

5. Do you have access to weather forecast information from the meteorological department?

[1] = Yes [2] = No

6. If the answer in (5) is yes, what are the primary sources of this information?

[1] = Newspaper [2] = Television [3] = Radio [4] = Extension worker [5] = Friends in the community [6] = Church [7] = Meteorological station [8] = Others

7. Do you have access to extension workers?

[1] = Yes [2] = No

Objective 2: FISHING COMMUNITIES PERCEPTION ON FISH CATCHES

1. Has there been any changes in your fish catches over the past 3 decades?

[1] = Decrease in fish catch [2] = Increase in fish catch [3] = No change

2. If the answer to question 1 is (1) or (2), what do you think attributes such changes in fish catches?

[1] = Overfishing [2] = Population growth [3] = Weak governance [4] = Poor fishing practices [5] = Changes in rainfall patterns [6] = Changes in temperature intensity [7] = Climatic hazards [8] = Others

3. Do you think climate change affects fish catches in the following ways?

[1] = Changes in fish production [2] Changes in migration of fish [3] = Changes in fish distribution [4] = Changes in reproduction patterns of fish [5] = Decrease in fish catch [6] = Increase in disease among fish [8] = Changes in fish species composition [9] = No change [10] = I don't know

4. How soon do you anticipate the effects of climate change will have an influence on fisheries and fish catch?

[1] = Already [2] = 1-10 years [3] = 11-30 years [4] = 31-50 years [5] = 51-100 years [6] = 100 years plus [7] = Never [8] = Don't know

5. How frequently do you experience poor fish catches over the past 30 years?.....

6. What other impacts do extreme weather events have on fishing activities?

[1] = Inability to go fishing [2] = Fishing vessel damage [3] = Loss of lives [4] = Low fish catch [5] = Fishing gear damage [6] = Fish kills [7] = Damage to landing sites [8] = Venturing further to catch fish [9] = Others

7. How do you earn your living during the closed fishing season?

[1] = off-farm labor [2] = farming [3] = Small businesses [4] = Still go fishing [5] = Boat repairing [6] = Others

Objective 3: COPING STRATEGIES TO LOW-FISH CATCHES

1. What impacts do changes in fish catches have on your livelihood activities?

[1] = Loss of income from fishing [2] = Abandoning fishing for other economic activities [3] = Reduced access to food due to loss of revenue from fishing [4] = Migration (change of fishing sites) [5] = Risk of malnutrition and under-nutrition due to reduced access to fish for a source of protein [6] = Others

2. In the face of low fish catches, what are your coping and adaptive measures

[1] = Farming [2] = Small scale business [3] = Boat repairing [4] = Off-farm labor [5] = Fish farming [6] = Migration to other fishing grounds [7] = Fishing during closed season [8] = Fishing using prohibited fishing gears [9] = Change targeted species [10] = Livestock farming [11] = Increased time on fishing grounds [12] = Do nothing [13] = Exit the fishery [14] = Others

3. How much of your monthly income comes from fishing?.....

4. Has the amount of money you make from fishing changed over the past 5 years?

[1] = Increased [2] = Decreased [3] = No change

5. If the answer in (4) is yes, explain why there's a change.

[1] = Less fish catches [2] = Less sales [3] = Lack of markets [4] = Others

6. Are you able to provide basic needs for your household from the revenue from fishing?

[1] = Yes [2] = No

7. If the answer in (6) is no, explain why?

[1] = Low income [2] = A large number of people in the household [3] = Low fish catch [4] = Others

8. How many meals do you have per day?

   [1] = Once a day [2] = twice a day [3] three times a day [4] Others

9. Are there periods during the year when your household has nothing or very little food to eat?

[1] = Yes [2] = No

10. If the answer in (9) is yes, explain why?

[1] = Low income [2] = Closed fishing season [3] = Low fish catch [4] = Others

SECTION C

KEY INFORMANT CHECKLIST

INTERVIEW WITH BVC LEADERS, NGOs, FISHERIES AND METEOROLOGICAL OFFICERS

1. Do you think the area has experienced changes in temperature and rainfall over the past 30 years?.....
2. What is the trend of these changes? Is it rising, declining, remaining the same, increased incidences of erratic rainfall, increased incidence of extreme temperature

   ……

   ……

   ……
3. How often do floods and droughts occur in your area? And what are the likely causes?

   ……

   ……
4. Have you noticed any changes in fish catch and species composition in the catch of fishers within the community in the past 30 years? (Fisheries off.) .....

   ……
5. Do you think climate change impacts fish catches? How? (Mete. and Fis. officer) .....

   ……

   ……
6. Does the community have access to weather forecasting information from your department? (Mete. officer) ……..
7. what are the sources for this information?.....
8. Are they traditional indicators that are used for predicting weather changes?.....

……

9. How do you think fishing-dependent households cope with climate change impacts?

……

……

10. What are your recommendations or suggestions on how to effectively cope with climate change impacts such as low fish catch?.....

……

……

11. What services are provided by your institution to fishing communities to support in addressing climate changes and climatic risks?.....

……

12. Do the changes in fish catch influence conflicts on fisheries resources?.....

……

13. How do your Institutions help fishermen cope with the shocks of climate change and changes in fish catch?.....

……

14. What are the barriers or limitations fishers face in coping with the adverse impacts of climate change?

……

……

FOCUS GROUP DISCUSSION GUIDE

FOCUS GROUP DISCUSSION WITH BEACH VILLAGE COMMITTEES, TRADITIONAL LEADERS, VILLAGE GROUPS

Fishing Community…….…….

Focus Group Size…….

1. Have you noticed any changes in rainfall and temperature in your community in the past 30 years?
2. What is the trend of these changes? Is it rising, declining, remaining the same, increased incidences of erratic rainfall, increased incidence of extreme temperature
3. How often do floods and droughts occur in your area? And what are the likely causes?
4. Have you noticed any changes in fish catch and species composition in the catch of fishers within your community in the past 30 years?
5. How have these changes affected the livelihoods of fishers and other community members?
6. What coping strategies have been employed by fishers and other fishing-dependent households to adapt to the changing climate and fish catches?
7. Have the changes in fish catch influenced conflicts or breaking of laws and regulations within the community?
8. Do you receive early warning information on short-term variations or long-term climate change from any sources?
9. What should the government do in support of deflecting the impacts of climate change in the area?

Appendix C: Tables showing Correlations between rainfall, temperature and fish catch

Correlations

		Log Temperature	Log Rainfall
Log Temperature	Pearson Correlation	1	-.655**
	Sig. (2-tailed)		.000
	N	68	68
Log Rainfall	Pearson Correlation	-.655**	1
	Sig. (2-tailed)	.000	
	N	68	68

Correlations

		Log Rainfall	Log fish catch
Log Rainfall	Pearson Correlation	1	.327**
	Sig. (2-tailed)		.006
	N	68	68
Log fish catch	Pearson Correlation	.327**	1
	Sig. (2-tailed)	.006	
	N	68	68

Correlations

		Log fish catch	Log Temperature
Log fish catch	Pearson Correlation	1	-.335**
	Sig. (2-tailed)		.005
	N	68	68
Log Temperature	Pearson Correlation	-.335**	1
	Sig. (2-tailed)	.005	
	N	68	68