ASSESSING THE IMPACTS OF CLIMATE CHANGE ON INLAND FISHERIES: A CASE STUDY OF LAKE MALAWI

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ABSTRACT

Climate change continues to be one of the major bottlenecks to global development and it has affected the fisheries sector. In Malawi, limited information is available on how the inland fisheries of Lake Malawi have been affected by climate change. A study to assess the effects of climate change on the inland fisheries of Lake Malawi was therefore conducted from December 2021 to February 2022. Primary data was collected from 90 respondents through the administration of a structured questionnaire. Literature review was used to further assess the impacts of climate change on the fisheries resources of Lake Malawi while drawing lessons from other countries. Data was analysed in excel, where pivot tables were formulated, and the gender dimensions of the fishery were also considered. Most of the respondents (76%) were male and mostly involved in fishing, the remainder were female mostly involved in fish trading and fish processing. This represents how the fish value chain is structured, men are the key players, while women are involved in the ancillary activities. Most respondents claimed that they have the knowledge and are aware of climate change and have experienced one or more extreme weather events, mostly floods and droughts. Rainfall has become erratic and starts late. There has been an increase in heavy Mwera winds which has affected their fishing activities. 73% of the respondents said that their income from fishing activities has decreased over the years. As a coping strategy, some respondents said they are involved in rainfed farming, an activity that is also vulnerable to climate change shocks. In terms of fishing, most of the fishers are going further offshore to catch fish, which may be dangerous considering the fishing gear used. Almost 60% of the respondents have access to general fisheries extension services, but not interventions from donor partners. Climate change information and early warning systems should be incorporated in fisheries extension messages.

Keywords: climate change, inland fisheries, gender, Lake Malawi, Malawi.

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LIST OF ACCRONYMS

BVCs	Beach Village Committees
DoF	Department of Fisheries
ENR	Environment and Natural Resource Degradation
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KII	Key Informant Interviews
LDCs	Least Developed Countries
MASL	Meters Above Sea Level
SDGs	Sustainable Development Goals
STs	Surface Temperatures
TAs	Technical Assistants
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

1 INTRODUCTION

Malawi's economy is heavily dependent on ecosystem services, and this makes the country highly vulnerable to impacts of Environment and Natural Resources degradation (ENR) and climate change. Agriculture, which is the mainstay of the economy accounts for 30 percent of the Gross Domestic Product (GDP) and 90 percent of the country's export earnings. Over 80 percent of Malawi's labour force is employed in this sector and most of the farmers are involved in subsistence farming (Government of Malawi, 2015). Similarly, the fisheries sector as one of the ecosystem services is important to the economy and livelihoods of Malawi's population. Nearly 65,000 fishers, living in rural areas are directly employed and 600,000 people are indirectly employed through ancillary activities along the value chain which include fish processing, fish marketing, boat building, and engine repair. Fish is an important food resource for Malawians, contributing 70% of dietary animal protein and 40% of the total protein supply; and to the nutrient requirements of the rural masses with per capita fish consumption of 9.6 kgs per year (Malawi Government, 2021).

The main provision of the fishery resource comes from capture fisheries. Even with the increase in the global consumption of fish and fish products in recent decades, the per capita fish consumption in Malawi has decreased during the same period (Hara, 2011). Combined effects of overfishing, habitat destruction, use of illegal gears, violation of closed seasons and protected areas, catchment degradation, and climate change have significantly caused unprecedented overexploitation of freshwater ecosystem fisheries (Dudgeon, 2012). This implies that unsustainable use of the fishery resource will negatively affect the fisheries sector, therefore affecting its performance in the long run (M'balaka, et al., 2018).

Climate change is considered the biggest challenge humanity is facing today. Due to its geographical position, Malawi has not been spared the negative impacts of climate change. It is projected that being one of the Least Developed Countries (LDCs), climate change will have serious impacts on all socio-economic sectors, with serious implications for the livelihoods of its population and its social and economic development (Government of Malawi, 2020). The factors that increase vulnerability to climate change impacts in Malawi are deep-rooted: poverty, rapid population growth resulting in overexploitation of natural resources, and high dependence on subsistence rain-fed agriculture.

The fisheries sector, which is essential to both the nutrition and livelihoods of most of the world population, especially in the developing world, has over time faced the negative impacts of overfishing, pollution as well as natural climate variabilities that often arise from extreme events, posing a serious setback to fisheries production (Deepananda & Macusi, 2012). On the other hand, there is low awareness of sustainable management of global inland fisheries despite their importance to the livelihoods of millions of people. Even though the impacts of climate change on marine resources have been mapped and are being addressed, there is not enough data to quantify the effects of climate change on inland fisheries. It is important to build resilient fishing communities which will be able to adapt to the negative impacts of climate change.

1.1 Problem statement and justification

Malawi is particularly vulnerable to climate change and variability. Observed changes in climate include a shift in the rainfall season, with late onset and cessation, as well as increases in the length of the dry season and reduction in the length of the growing season. According to UNDP country profile for Malawi, temperature increased by 0.9°C between 1960 and 2006, at an average rate of 0.21°C per decade, with the highest increases during December-February (mid-summer) and lowest during September-November (early summer) as shown in figure 1.1 (McSweeny, et al., 2012). An Economic Vulnerability and Disaster Risk Assessment demonstrates that whilst drought poses a more extensive threat than floods in terms of geographical range and economic effects, floods are more common and cause severe economic hardships. The lakeshore areas of Lake Malawi also experience these flooding events (IFPRI/RMSI, 2010).

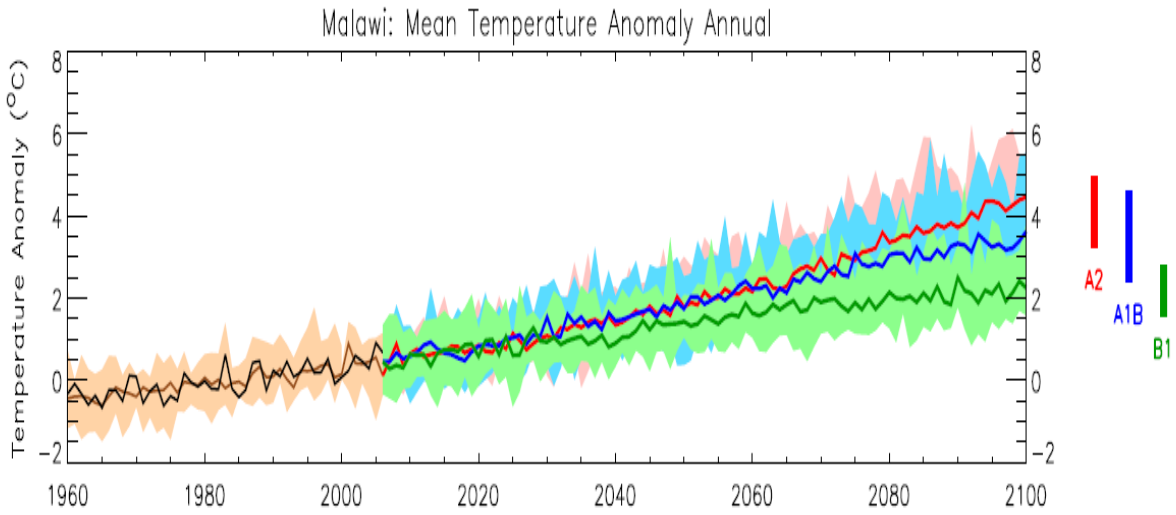

Figure 1.1. Trends in annual and seasonal mean temperature for the recent past and projected future. Source: *(McSweeny, et al., 2012)*.

Little information on how the inland fishery in Malawi has been affected by climate change is available, despite showing a significant decline in catches and a change in species composition in the catches over the years. The fisheries sector is facing both internal and external pressures such as land degradation, pollution, and other anthropogenic factors (external) and dwindling of fish catch due to pressure on the fisheries resources (internal) and this is exacerbated by the effects of climate change. Fishers can no longer catch the highly valued *Oreochromis* (Chambo) species, and they are currently going offshore to catch the pelagic schooling Lake Malawi sardine *Engraulicypris sardella* (Usipa). This is hampered by an increase in extreme weather events as the fishers are already forced to search for fish further offshore and hence regularly encounter more severe weather, while taking longer to reach the safety of the shore because they use primitive fishing gears. (FAO, 2018).

Figure 1.2. *Oreochromis karongae* (Chambo*),* left, and *Engraulicypris sardella* (Usipa), right.

It is therefore important to examine the effects of climate change on the livelihoods of fishing communities and come up with possible adaptation options to help strengthen the resilience of those dependent on the fishery resource. The National Aquaculture and Fisheries Policy, which is the overarching strategy for the sector, should clearly indicate key priority areas on how to address this important global issue.

Lake Malawi, which is the third largest in Africa after Lakes Victoria and Tanganyika, is an important economic resource to Malawians, boasting about 800 endemic fish species. It is considered a world heritage site as it is home to more diverse fish species than any other water body in the world (Weyl, et al., 2010). The Lake is also home to rock-dwelling aquarium fish species, Mbuna which are exported live globally to be used in aquariums. Although a large quantity of fish produced within Malawi is consumed locally, the nation derives a significant amount of foreign exchange from exporting fish. It is estimated that more than 500 tonnes of fish are exported annually (Government of Malawi, 2016).

1.2 Goal

To assess the impacts of climate change on the inland fisheries of Lake Malawi, particularly Nkhotakota District.

1.2.1 Objectives

i. To explore how climate change has impacted the livelihood of the fishing communities in Nkhotakota District.
ii. To identify possible adaptation options for the small-scale inland fishery in Malawi.

1.2.2 Research questions

i. Has climate change had any effects on the livelihood of the fishing communities on Lake Malawi, particularly in Nkhotakota district?
ii. What are the possible climate change adaptation options for the small-scale fishing communities in Nkhotakota?

2 LITERATURE REVIEW

2.1 The importance of inland fisheries sector

The contribution of inland fisheries to livelihoods, food security and sustainable development is often overlooked by prioritizing ocean issues on one hand and in global-level discussions about food systems and security on the other hand. This setback comes at a time when fish is one of the most consumed foods and traded commodities in the world, providing food, jobs and life satisfaction to billions of people worldwide (Funge-Smith & Bennet, 2019; Loring, et al., 2019). The small-scale fishery sector's contribution to economic growth, food and nutrition security at household, local and national level should never be understated, even though its fisheries activities are mostly informal (FAO, 2020).

Fish is currently among the most eaten foods and traded commodities in the world (Arthur, et al., 2021). Global fish consumption has increased from 9 kgs per capita per year in 1961 to 20.3 kgs per capita per year in 2017, at an average rate of 1.5% per year and this is higher than the increase in consumption of any other food products (FAO, 2020). There is a need to ensure that fisheries issues are included in food security and poverty related policies. Africa accounts for 25 percent of the global inland catches from the wild and provide between 32 per cent and up to 70 per cent of total animal protein consumed (Heck, et al., 2007). Given the fact that a significant percentage of the population is malnourished and battling with epidemic diseases such as HIV/AIDS, fish as a food system could address such issues and contribute to a healthy population.

The inclusion of the fisheries sector in food systems would contribute to the achievement of Sustainable Development Goals (SDGs) and help mitigate climate change issues by increasing the availability, stability and utilization of the fishery through sound policies. The contribution of fisheries to food security at both household and national levels through direct and indirect contributions has particularly been highlighted by the United Nations Food and Agricultural Organisation (FAO) (Sowman & Cardoso, 2010).

2.2 Climate change as a driver for a decline in fish catches in inland lakes

Studies have shown that inland fisheries face many challenges to their sustainability such as urban encroachment, environmental degradation, and human-induced climate change, posing a threat to the majority of the world's 200 million full and part-time fisherfolk directly and indirectly employed in the sector (Utete, et al., 2018). High climate variation has a significant effect on the distribution and productivity of the fisheries resources, even though relationships between the biophysical impacts of climate change and the livelihood vulnerability of poor fishing communities have seldom been investigated. Scanty information on the areas and people that are likely to be the most vulnerable to climate-induced changes in the fisheries is available. However, this information is required for the effective prioritization of development interventions to reduce vulnerability to the impacts of adverse climate change on fisherfolk living in poverty (Allison, et al., 2005)

It has also been observed that there is a link between climate change and other factors affecting the fishery, some of which include anthropogenic activities such as land-use changes which affect the balance between inputs and outputs of nutrients and sediments, as well as changes in food-web dynamics in the freshwater ecosystem (Arthur, et al., 2021). This is due to the fact that the fishery is vulnerable to environmental changes because fish are ectothermic and fish distribution is usually limited by structural thermal and chemical barriers. In the long run, this has been linked to major shifts in fish catches (Kao, et al., 2020). Understanding the

impact of climate change requires time-series data and lack of data has restricted the assessment on how the inland fishery has been affected by climate change events.

There is enough evidence to show that African inland freshwater ecosystems are changing due to climate variability though at a small-scale. For instance, elevated Surface Temperatures (STs) have been reported for the Lakes Kariba, Kivu, Tanganyika, Victoria and Malawi. It has also been reported that increased temperatures have caused a decrease of approximately 30 percent in fish yields in Lake Tanganyika, East Africa (Seggel & De Young , 2016).

2.3 An overview of Malawi in the face of climate change

Malawi as a country is highly vulnerable to climate change (Deepananda & Macusi, 2012). It has the lowest per capita income in the world, with more that 50 percent of its population living below the poverty line. Agriculture is the mainstay of its economy, contributing nearly 40 percent of Gross Domestic Product (GDP) and roughly 90 percent of the country's export earnings, with fishing a predominant activity in the lakeshore areas (along Lake Malawi). Small-scale fisheries in Malawi contribute 95% of fish catches and the fish is mostly consumed locally (USAID, 2021). In addition to unsustainable fishing practices, the fishery resource is also under pressure from climate change, which impacts fish biology, reproduction, productivity, and habitats. It has been estimated that Malawi loses an average of 1.7% of its GDP from climate change-related disasters, mainly floods and drought (IFPRI/RMSI, 2010).

Table 2.1. Annual economic losses by countries worst hit by extreme weather events in Africa in 2019. Source: *(Eckstein, et al., 2021)*

Country	Fatalities	GDP loss	Loss monetary millions
Mozambique	700	13	$4.9 billion
Zimbabwe	347	4	$1.8 billion
Malawi	95	2	$452 million
South Sudan	185	1	$85 million
Niger	18	1	$219 million

It has been noted that the water bodies in Malawi are susceptible to climate changes, for instance there was a period between 1915-1935 when Lake Malawi was closed and there was no outflow of Shire River. The lake nearly became closed in 1997 due to low precipitation (Ministry of Forestry and Natural Resources , 2021). Lake Malawi is known to be permanently stratified and it is anoxic below depths of about 170–200 m. Temperature has a great influence on the processes in the lake, for instance at shallower depths, water temperatures and lake stratification follow seasonal patterns. In the months between September and December there is a warming of the surface waters and stratification intensifies. By May the upper 60–80 m is homothermic at about 27°C; during the cool windy

season the thermocline weakens so that by July it is poorly defined and there is a gradual temperature gradient of 23°C at the surface to 22.5°C at 250 m (Weyl, et al., 2010).

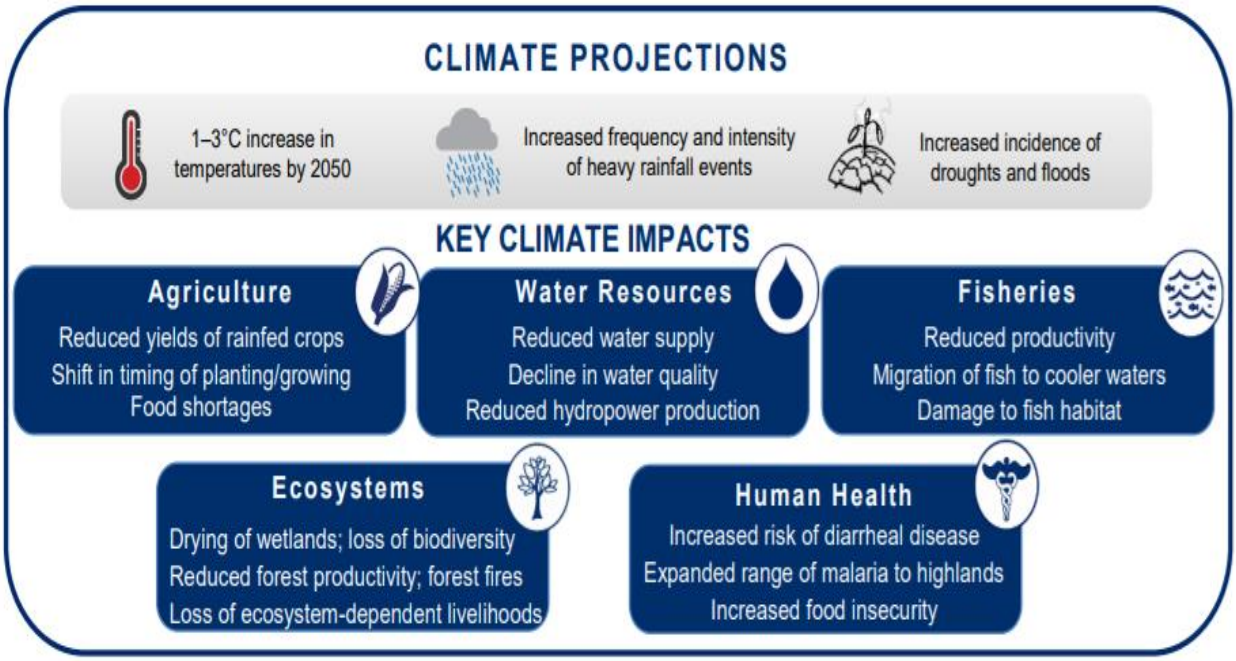

Figure 2.1. Climate projections for various sectors in Malawi. Source: USAID

2.4 Weather patterns in Malawi

There is overwhelming evidence that global air temperatures are changing with time. Over the last four decades, rainfall and air temperatures in Malawi have exhibited an increasing trend, and extreme weather events are more common with an increased intensity, frequency and magnitude of floods and droughts. For instance, from 1970 to 2008, Malawi has experienced more than 40 weather-related disasters, with 16 of these occurring between 1990 and 2008 (Republic of Malawi, 2011). These extreme weather events adversely impact on food security, natural resources, and sustainable livelihoods of family households.

2.4.1 Rainfall trends

Over the last two decades, Malawi has been affected by climate variability and change, experiencing greater incidences of dry spells and intense rainfall. These have in turn lead to an increase in the frequency of floods, droughts, pest, and disease outbreaks, with severe economic and social consequences. According to the Second National Communication report to the UNFCCC by the Malawi Government (2011), Malawi has experienced several climatic variations that have resulted in the occurrence of extreme weather events, ranging from droughts (1991/92) to floods (1996/97) and flash floods (2000/01). When there were floods in the Southern Region during the 1996/97 crop season, the Lakeshore Plain, experienced drought conditions. These extreme occurrences within the country clearly illustrate that there are large temporal and spatial variations in the occurrence of extreme weather events. Furthermore, there are large decadal rainfall fluctuations, with a clear decreasing trend for mean seasonal rainfall in the Lakeshore areas (Republic of Malawi, 2011).

Even though scanty information on extreme weather events exists at national level, it has been evidenced that high rainfall intensity and large rainfall variations have a direct effect on the occurrences of extreme weather events such as flush floods and prolonged droughts. Rainfall

has been varying over time, but the long-term trend showed a decreasing trend like the runoff inflow into the Lake (Kaunda, 2016).

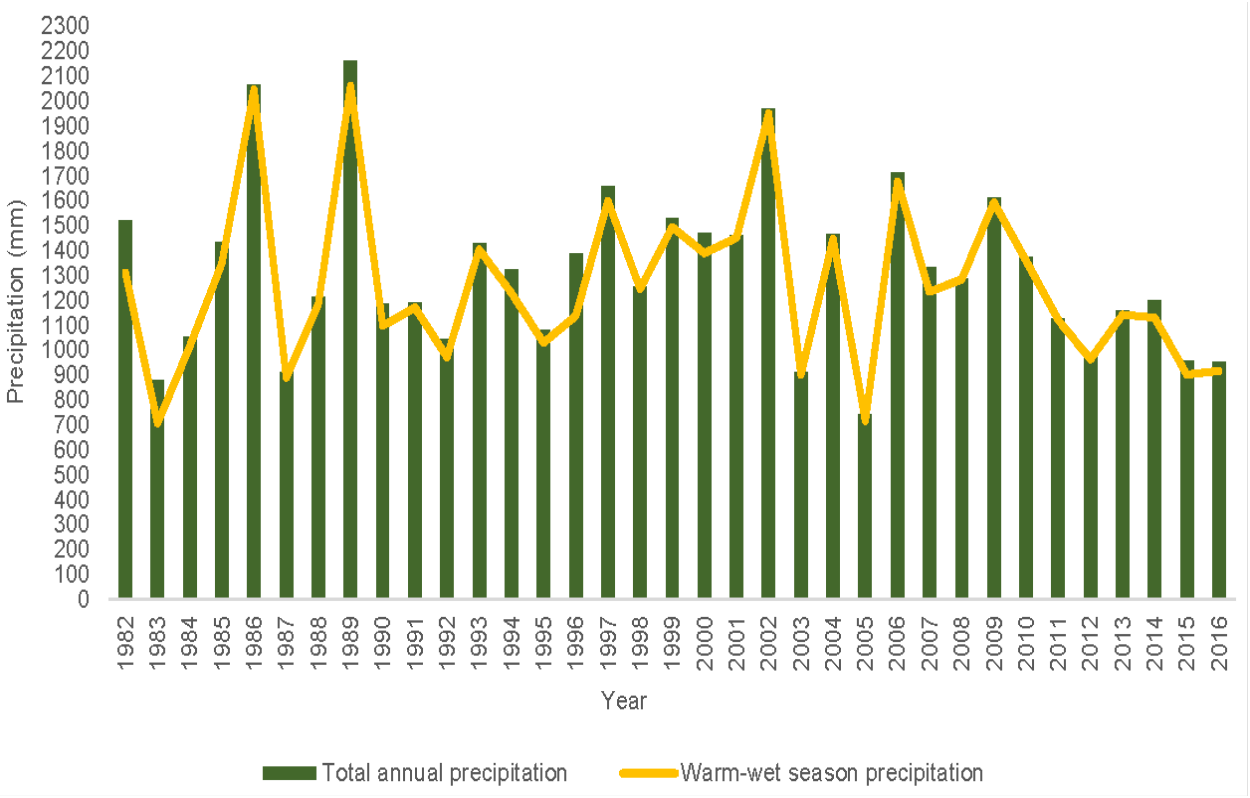

Figure 2.2. Mean total annual and warm-wet (December to March) season precipitation (mm) for Dwangwa, Nkhotakota, Malawi from 1982–2016. Source: *(Limuwa, et al., 2018).*

2.4.2 Temperature trends

Historical observations indicate the average annual temperatures have risen by 0.9°C between 1960 and 2006 with changes in patterns of El Niño and La Niña, thus increasing climate variability and uncertainty. Climate projections indicate an increase in average annual temperatures and floods, with natural disasters being declared around lake Malawi in the last few decades, including droughts (1991-1992) and floods (2000-2001) (Government of Malawi, 2019).

Though there is inadequate evidence and records in terms of impacts of climate change on Lake Malawi fisheries, ample evidence suggests that global mean temperatures which have increased from 0.3°C to 1.09°C in the last century, and 2021 was 0.18°C to 0.26 °C warmer than 2011 (World Meterological Organization, 2022). This is an indicator of serious threats on the survival of both marine and freshwater fish species (Makwinja & M'balaka, 2017). Studies have shown that there is a warming trend in the surface waters of Lake Tanganyika, and in the surface and deep waters of Lake Malawi (Powers, et al., 2011). There is also strong evidence to show that the temperature of the deep water below 300 meters in Lake Malawi has increased by 0.78ºC over the last six decades (Kumambala & Ervine, 2010; Vollmer, et al., 2005). This is mainly due to the reduction of cold-water deep convection over this period, which is associated with milder winters in the sub-Saharan region. According to Vollmer et al., (2005), the results indicate that the vertical density stratification over the full depth range has weakened during the summer months over the observed period. Another study has shown that there has been a warming trend in Malawi with the mean temperatures increasing from an average of 22.0 °C in 1961–1970 to 22.6 °C in 1991–2000 over the period of 1961 to 2005

(Warnatzsch & Reay, 2019). This is in line with Conway et al., (2005) who stated that there were rainfall fluctuations in East Africa in 1961, followed by very high rainfall in 1963 and a succession of wet seasons during the late 1960s through to the early 1980s and the effects were spread from the Equator to as far south as Lake Malawi. The same study also reported that from 1961–1964 the cumulative river flow anomaly for the White Nile upstream of the Sudd (Lakes Victoria, Kyoga, Edward and Albert), plus the Blue Nile, Atbara, Congo, Tana and Zambezi rivers was 1428 km^3, roughly equivalent to the mean annual flow of the Congo and after another event in 1997, the level of Lake Victoria rose by 1.7 m by 1998, Lake Tanganyika by 2.1 m and Lake Malawi by 1.8 m.

These temperature changes affect fish migration, spawning times, species distribution and the overall productivity of lake Malawi fisheries (Republic of Malawi, 2011). According to the Fifth Assessment Report on Climate Change, extreme weather events are expected to become more frequent and more intense as the climate changes, though with large regional variations and differing degrees of confidence depending on the type of climate event. However, climate change has already led to changes in freshwater and marine ecosystems in eastern and southern Africa, and terrestrial ecosystems in southern and Western Africa (IPCC, 2014).

2.4.3 Lake Malawi water levels

Geological evidence supports the view that Lake Malawi water levels have been fluctuating since time immemorial as shown in figure 2.3. According to Kaunda (2016) and Bhave et al., (2020), Lake Malawi is very sensitive to climate variations where the cyclic fluctuations in levels are largely subjective to annual rainfall patterns. The lowest lake water levels were recorded in 1916 at 469 Meters Above Sea Level and in the recent past, the lowest recorded was at 472.94 MASL in 1997 and very recently in 2015 at 473.32 MASL (MoIWD, 2015). Climate change is expected to reduce the water level yield by 8.84% based on simulations for the near future from 2036 to 2065 and the far future from 2066 to 2095 (Kaunda, 2016). The changing water levels could have an impact on the type and amount of fish catches, regardless of the anthropogenic factors that have led to a significant decline in fish catches. For instance, substantial quantities of fish from Lake Malawi catchment which include the cichlids have diverged from the parent population over time in response to climatic conditions and fluctuating water levels (Republic of Malawi, 2011).

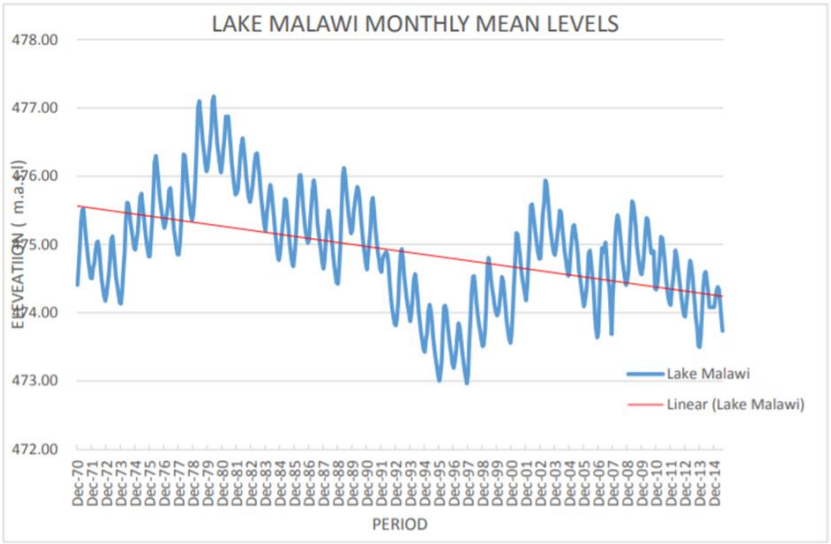

Figure 2.3. Lake Malawi monthly mean levels from 1970 to 2015. Source: Kaunda, 2016

2.5 Sustainability issues that would limit the assessment of climate change on Lake Malawi

Fisheries management in Malawi continues to be challenging due to over exploitation of fish stocks and various anthropogenic activities resulting in a reduction of genetic resources (Kassam, et al., 2017). This has led to a decline in fish catches with other fish species being listed on the IUCN endangered species list. *Opsaridium microlepis*, locally known as Mpasa and *Oreochromis karongae,* locally known as Chambo are the most threatened fish species in the Lake. In response to the declining fish catches, fishers have resorted to using unsustainable fishing methods, such as cheaper and destructive fishing gears in order to catch more (Hara, 2011). Mpasa is commonly found in the Northern and Central parts of Lake Malawi, and it is heavily exploited by gillnets set near the river mouths during its migration from the lake to breed in the rivers (Kassam, et al., 2017).

Figure 2.4. *Opsaridium microlepis* (Mpasa)

Being a large open water system, it has proven difficult to control the fishery of Lake Malawi unlike other water bodies. With this weak governance system, there are several challenges and threats that continue to impact on the ecosystem health of Lake Malawi (M'balaka, et al., 2018). This has led to overfishing mainly due to rampant use of under-sized-meshed nets, trawling in undesignated areas, degradation of the environment by clearing aquatic weeds in cottage developed shore areas; and the ‘open access’ nature of the fisheries leading to increased fishing effort in terms of gears and fishers (Njaya, 2018). With all these factors, it would be difficult to quantify the factors that are being driven by climate change.

3 METHODOLOGY

3.1 Study area

The study was conducted in the central parts of the west coast of Lake Malawi, particularly in Nkhotakota district in three landing sites namely, Bondo, Liwalazi and Matumbi which were identified through random sampling (figure 3.1). Nkhotakota district is in the central region along the shores of Lake Malawi. The district, which is one of the major fishing districts in Malawi has the longest shoreline than any other district at 350 kilometers. The Bua river, which is a tributary of major importance and a breeding ground for salmonids fish species such as Mpasa and Ntchira, flows into Lake Malawi in this district. These fish species are migratory, spending most of their life in the lake and are currently on the International Union for Conservation of Nature (IUCN) red list.

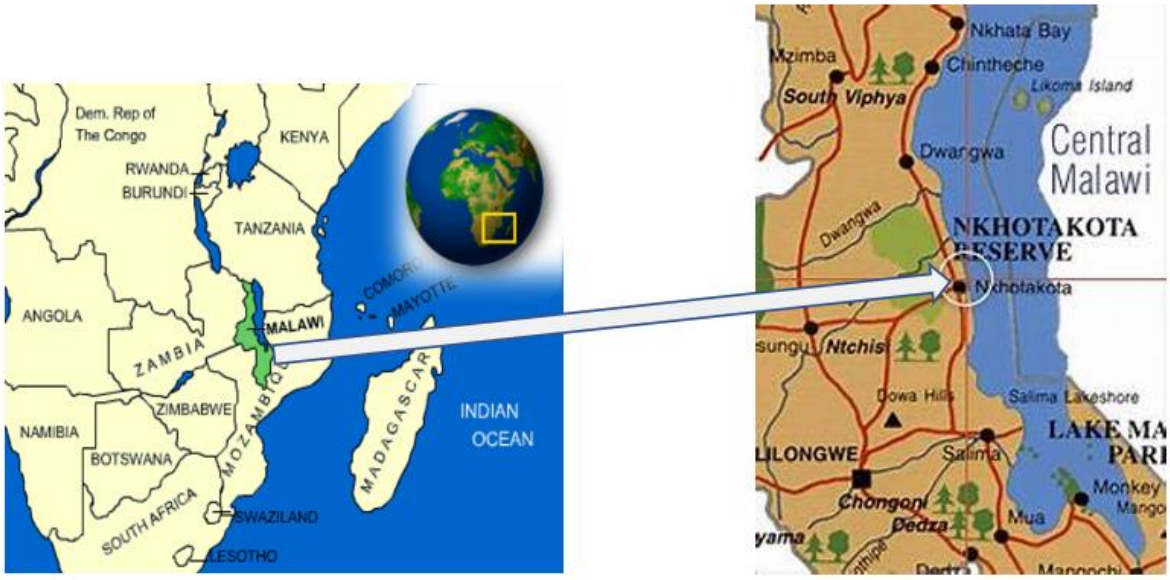

Figure 3.1. Map of Southern Africa showing location of Malawi (left) and map of central Malawi showing location of Nkhotakota.

3.2 Data collection

This study incorporated quantitative research methods in data collection and analysis with the purpose of providing a better understanding of the research topic. Primary data and information were collected in Nkhotakota district between 26th and 31st December 2021 through administration of a structured questionnaire to ask both open and close-ended questions. The landing sites were randomly sampled from a list of active landing sites to collect data from fish value chain actors consisting of gear owners, crew members, fish traders, fish processors and boat builders. Information collected was on the effects of climate change on the livelihood of the value chain actors, their coping and adaptation strategies and their access to climate change information (appendix 1). The structured questionnaires were administered to the fish value chain actors through face-to-face interviews. The formulated questionnaire was pre-tested prior to the commencement of the information gathering exercise to ensure it was capturing data that will be key to addressing the project objectives.


Figure 3.2. respondents captured during data collection.

- Literature review was conducted to assess the impact of climate change on the physical parameters (rainfall, temperature and water levels). This is due to lack of time series data which would have been used to analyze this information (see section 2.4).
- Relevant literature was also synthesized to understand the impacts of climate change on small-scale inland fisheries and identify the adaptation options for the sector. It is expected that in the long run, this will contribute to the formulation of climate change adaptation measures on inland fisheries of Lake Malawi.

3.3 Data analysis

The survey data was inputted into google forms then exported to Excel 365 to analyse the effects of climate change on the livelihoods of the fishing communities. Descriptive statistics were used as an analysis tool to present the socio-demographic characteristics, climate change stressors and livelihood adaptation methods as designed in the questionnaire. Pivot tables were used to analyse the data which was then plotted into graphs. Gender dimensions of the study were also taken on board.

3.4 Limitations of the study

Lake Malawi fisheries, being a large open access fishery has been faced with overexploitation due several factors. This has overtime led to the collapse of Mpasa fishery and the Chambo fishery and currently, juvenile Usipa is being exploited (refer to section 2.7). Being a very big lake, it is also very difficult to quantify the effects of climate change. It is however believed that in the long run, the results will trigger more research or help make informed decisions in terms of adaptation and resilience of the fishing communities to climate change. It is imperative to note that global climate has changed over time, and it is affecting other sectors. This may either add pressure on the fishing communities or even affect the lake in one way or the other. It is therefore important to assess the effects of climate change on the fisheries resources and identify possible adaptation options for the fishery sooner rather than later.

4 RESULTS

4.1 Overview of the results from interviews with value chain actors

Three landing sites; Bondo, Matumbi and Liwaladzi in Nkhotakota District were randomly selected, and 90 respondents were involved in the study. Out of the 90 respondents, 66 were male and 24 were female, representing an overall percentage of 73% and 27% respectively. The percentage of respondents by landing site are shown in figure 4.1 below. It is worth noting that in the fish value chain, the majority are men, so it is not surprising to see that there were fewer women than men in the landing sites.

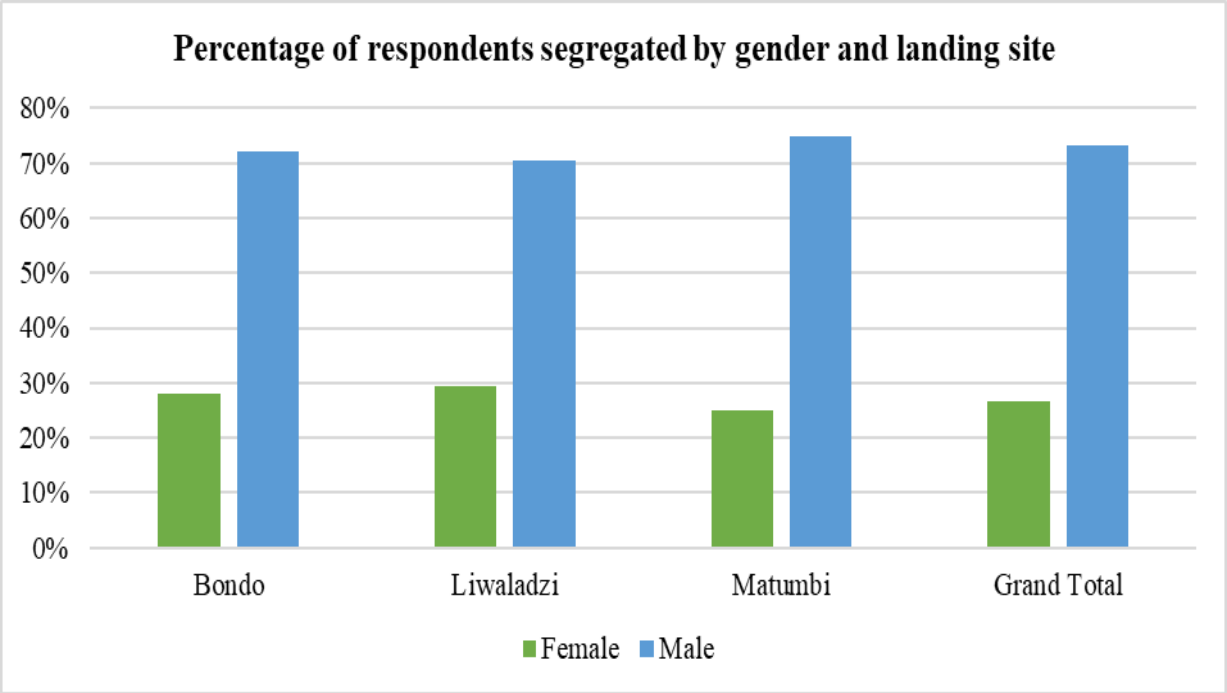

Figure 4.1. Percentage of respondents segregated by gender and landing sites.

Out of the females interviewed, 71% were fish traders and 29% were fish processors. The majority of male respondents (70%) were fishers, the rest were distributed into fish traders (21%), fish processors (6%) and boat builders (3%) as shown in figure 4.2 below.

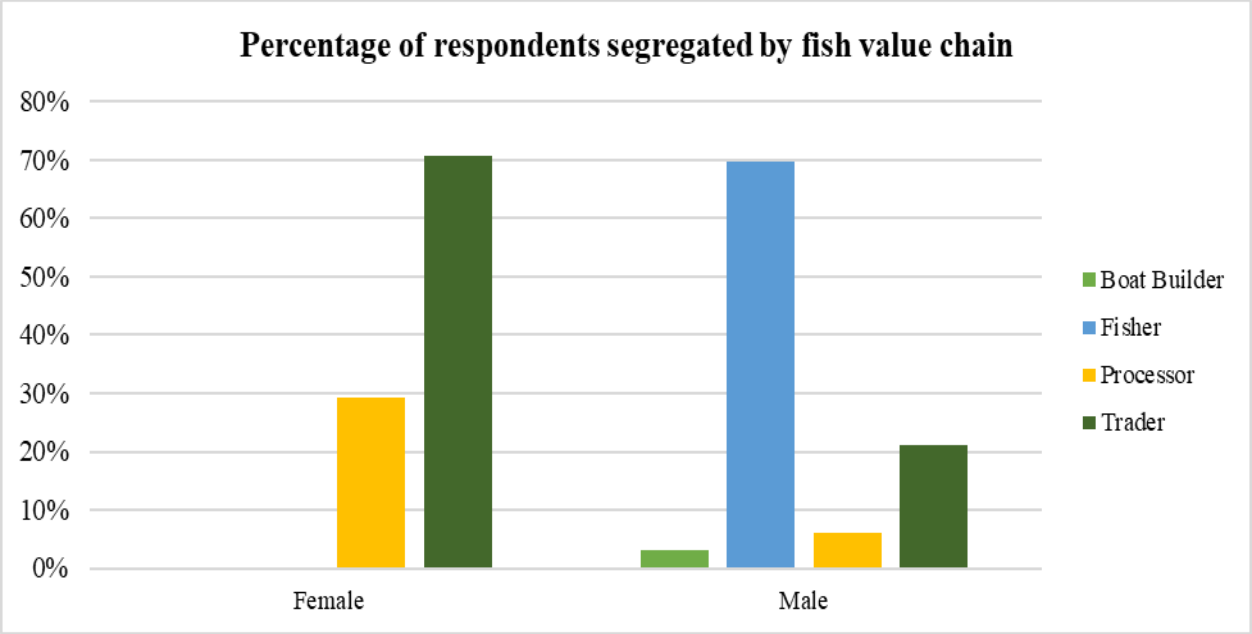

Figure 4.2. Percentage of the respondents segregated by gender and fish value chain.

When asked about the number of years they have been in the fish value chain, the majority of the males (58%) and females (42%) said they have been in the fish value chain for more than 10 years (figure 4.3).

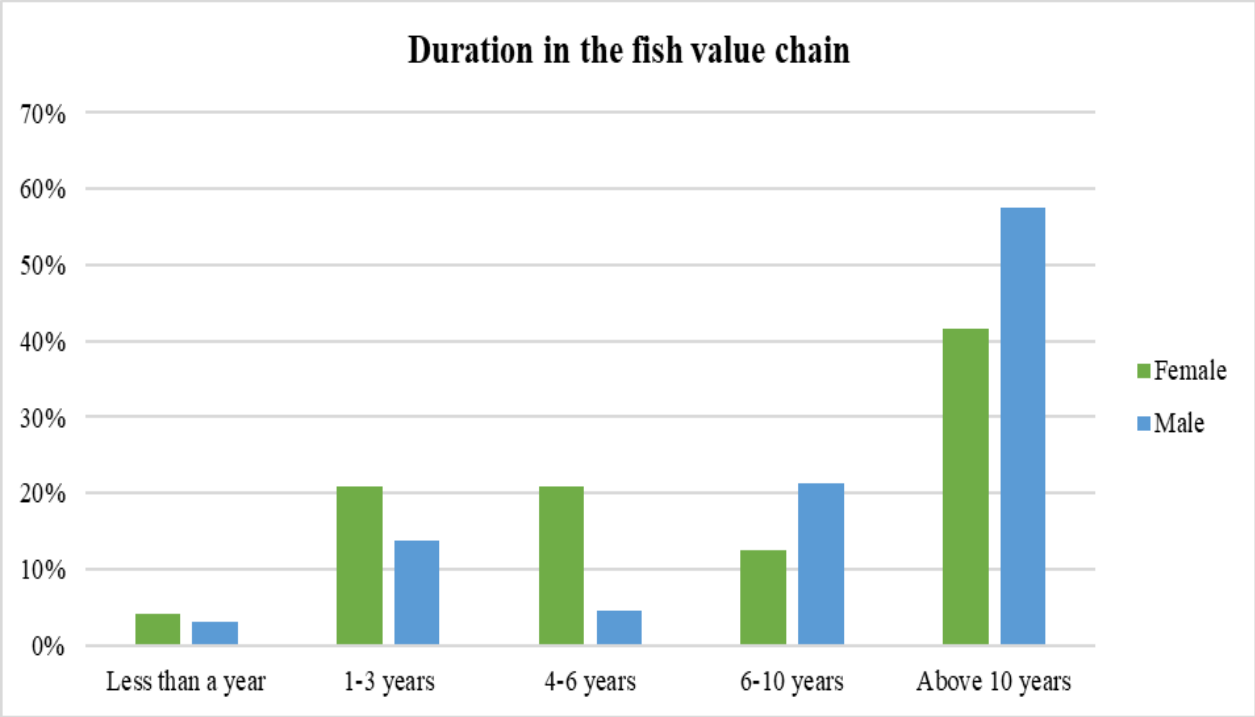

Figure 4.3. Duration in the fish value chain segregated by gender.

4.2 Climate change effects on the livelihoods of the respondents

4.2.1 Knowledge and awareness about climate change issues

Results in figure 4.4 below show that a higher percentage of men believe they have some or good knowledge about climate change than the corresponding percentage of women. However, when it comes to awareness on climate change issues, the percentage of women who claimed to have some or good awareness is slightly higher than that of men. The respondents claimed to have started experiencing extreme weather events in the early 2000s.

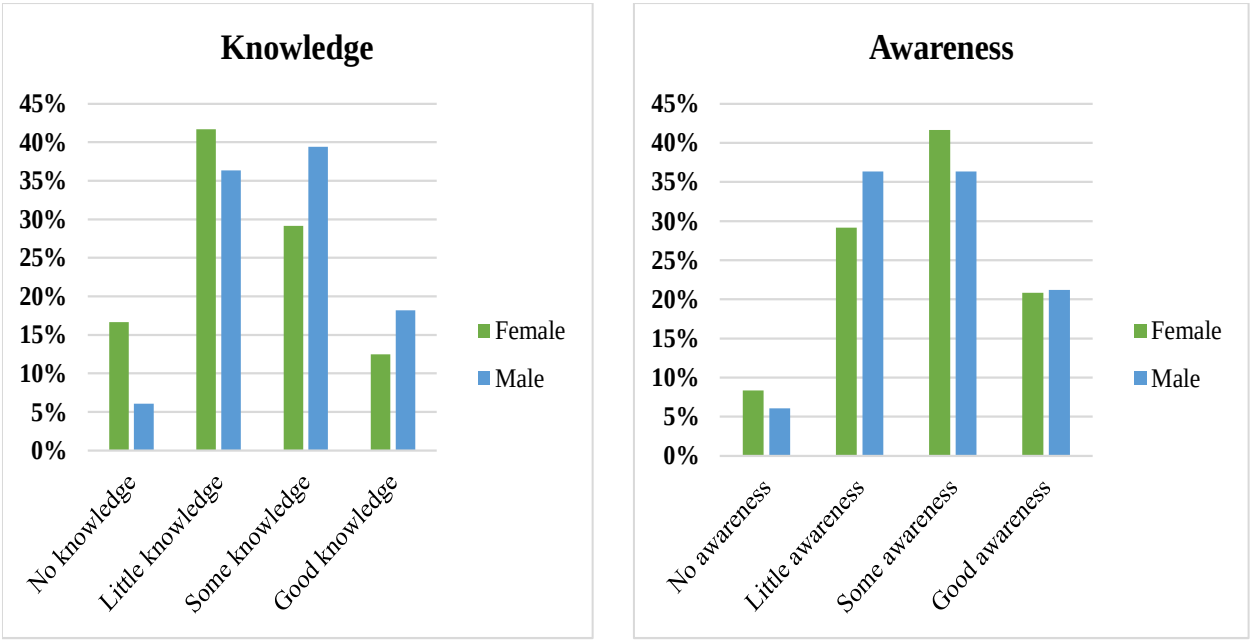

Figure 4.4. Knowledge (left) and awareness (right) of climate change by the respondents segregated by gender.

4.2.2 Drought and flood incidences that have been experienced over the years

From the responses shown in figure 4.5, a similar percentage of males (83%) and females (80%) said they have experienced 1 to 5 drought incidences. However, when asked about flood incidences, the percentage dropped to 67% for men and 79% for women. More men (26%) claimed to have experienced flood incidences than women (13%).

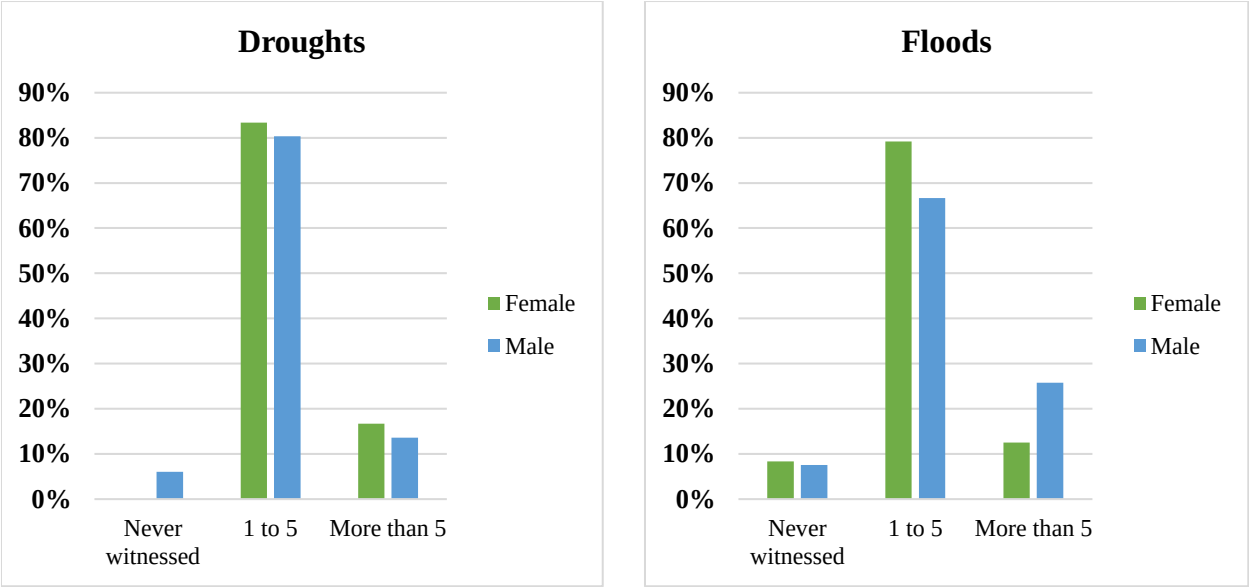

Figure 4.5. Number of drought incidences (left) and flood incidences (right) that have been experienced over the years segregated by gender.

4.2.3 Observed changes in rainfall and weather patterns over the years

The respondents claimed that rainfall patterns in the district have changed over the years, with the rains coming late and are usually erratic. Their responses in percent distribution are shown in figure 4.6 below:

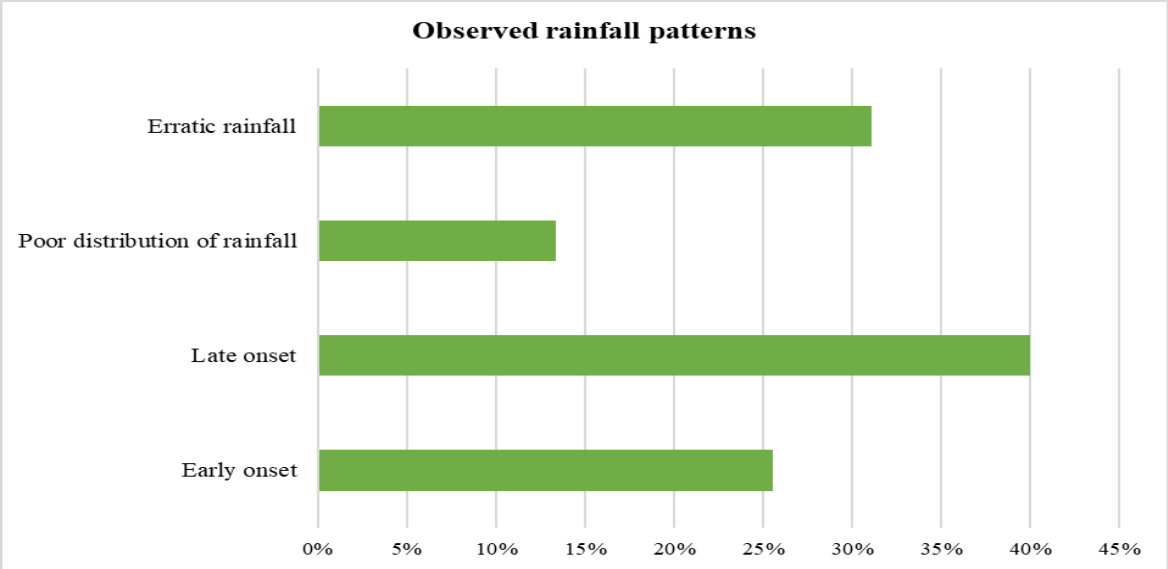

Figure 4.6. Observed changes in rainfall patterns over the years.

In terms of weather patterns that have affected their fisheries activities, most respondents (89%) answered that heavy Mwera winds (south-easterly winds) are having a negative impact on their business in terms of low catches or even not going to the lake to catch fish during the incidences of Mwera winds, followed by heavy rains (11%) as shown in figure 4.7.

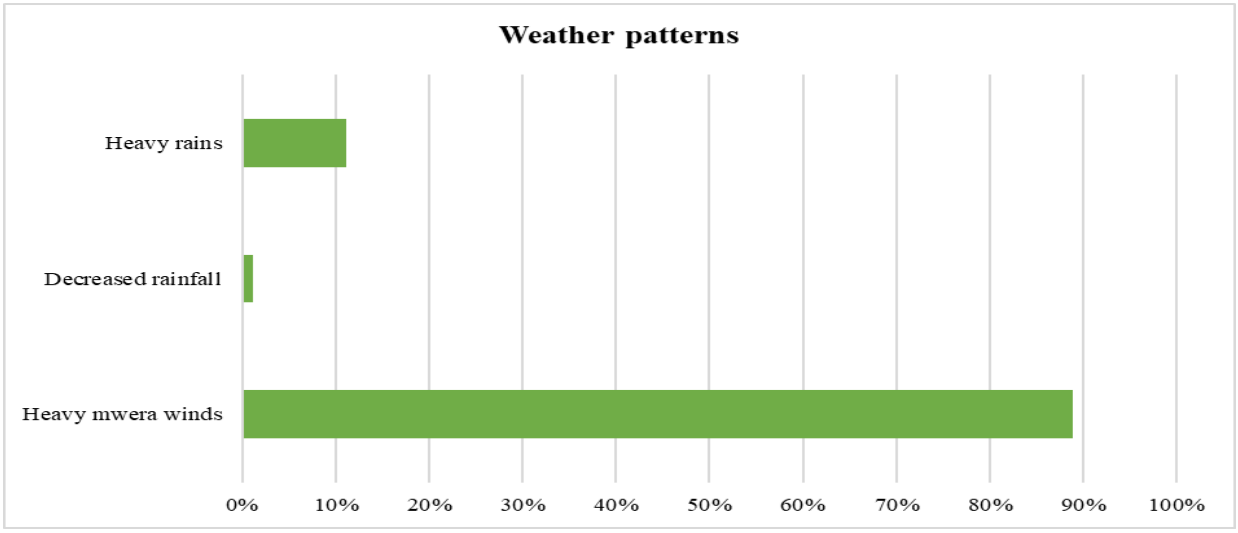

Figure 4.7. Weather patterns that have negative impacts on the respondents' fishing business

Common weather events as mentioned by the respondents in figure 4.8 include late rains, persistent winds, dry spells and extreme temperatures.

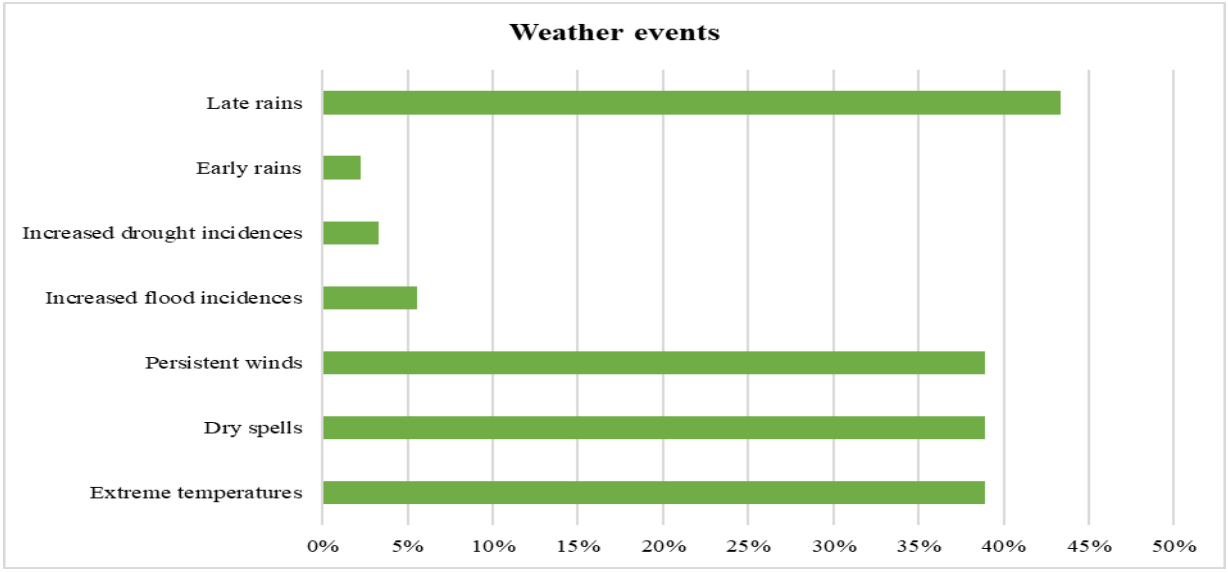

Figure 4.8. Common extreme weather events

During episodes of extreme weather events the respondents claimed that fish catches are low and this affects all fish value chain actors; the fishers because they are not able to fish, the traders and processors are not able to order fish to sell or process and the little available fish becomes very expensive. The respondents also claimed to have experienced damaged fishing gears and vessels and consequently, loss of lives (figure 4.9).

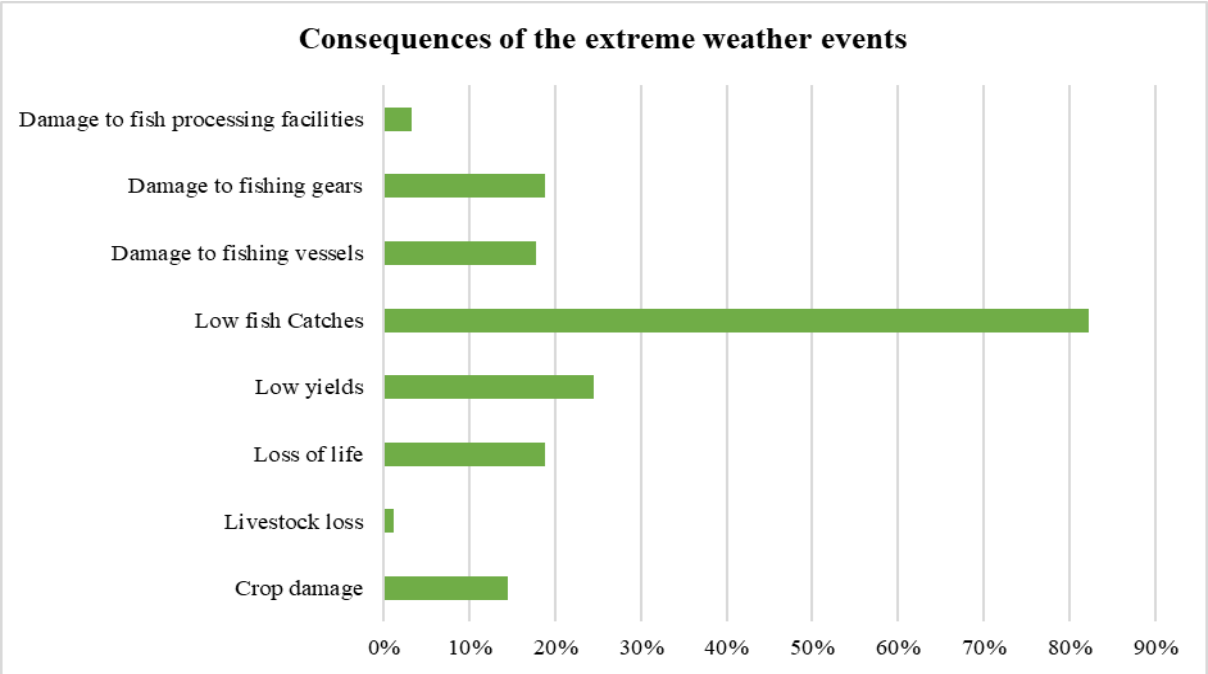

Figure 4.9. Consequences of the weather events

4.2.4 Observed climate change impacts as described by the respondents

In terms of fish catches, a majority of the respondents (figure 4.10) claimed that they are catching less fish, with 53% of the males claiming that there is less of the same fish species and 54% of the females claiming that there is less and different fish species.

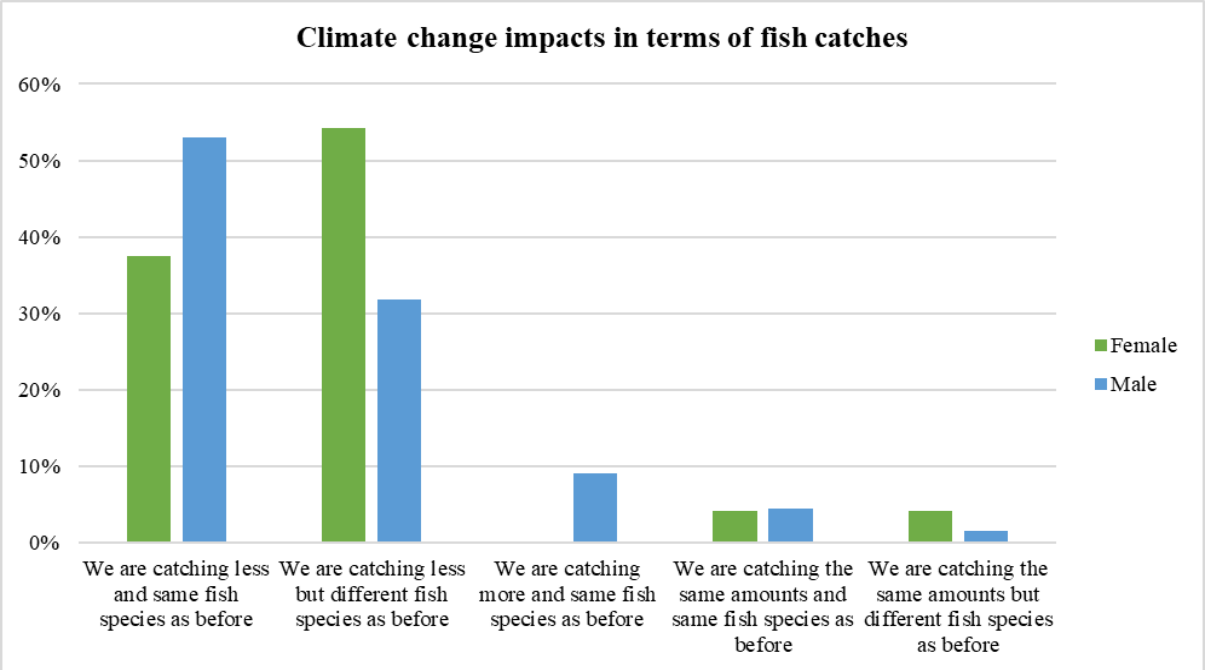

Figure 4.10. impacts of climate change in terms of fish catches

In terms of fishing grounds (figure 4.11), both genders responded that fishing grounds have changed over the years as fishers are now going further offshore to catch fish than it was before.

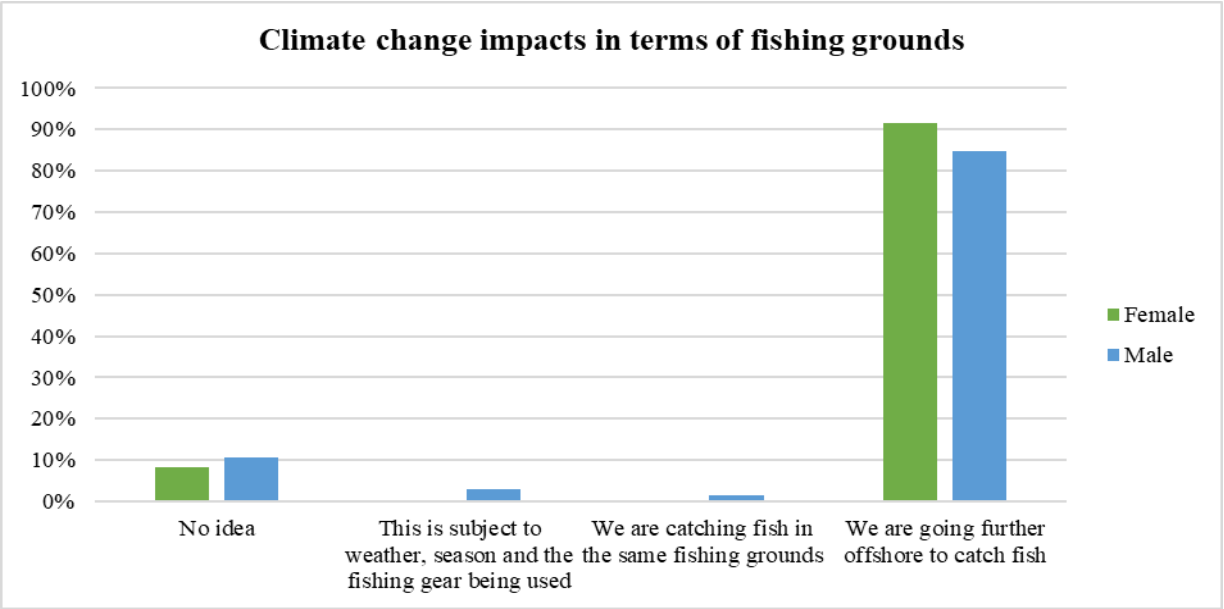

Figure 4.11. Impacts of climate change in terms of fishing grounds

In terms of fishing gears used (figure 4.12), 63% of the female respondents did not have any idea, possibly because they are not involved in fishing activities, 39% of the male respondents claimed that they are using the same fishing gears to catch fish, while the majority of the males (47%) claimed to have upgraded their fishing gears in order to catch more fish.

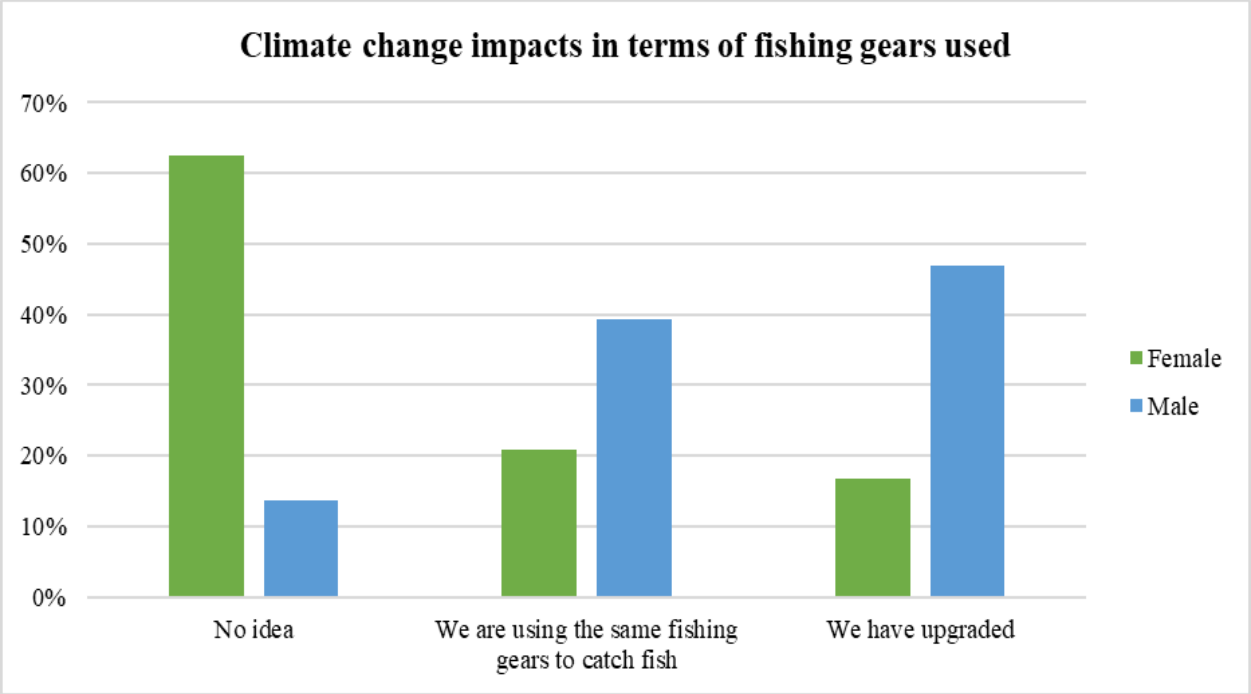

Figure 4.12. Impacts of climate change in terms of fishing gears used.

Other climate change effects as mentioned by the respondents include low crop yields, unreliable weather patterns, damage to fish processing facilities among others.

4.3 Coping and adaptation mechanisms identified during the study

4.3.1 Changes in income from fishing activities

When asked whether their income has changed over the years, 73% of the value chain actors claimed that their income has decreased, 16% respondents said that it has increased, while 11% of the respondents claimed that their income has remained the same (figure 4.13). The reasons for the change in income given by the respondents include decline in fish catches, influx of exported fish in the markets such as *dagaa*, high inflation and depreciation which is increasing the operation costs and making their businesses unstable among other reasons. In terms of alternative sources of income, 36% of the respondents said they have no source of alternative income and 52% of the respondents said they are involved in rainfed farming, which is also prone to climate related shocks.

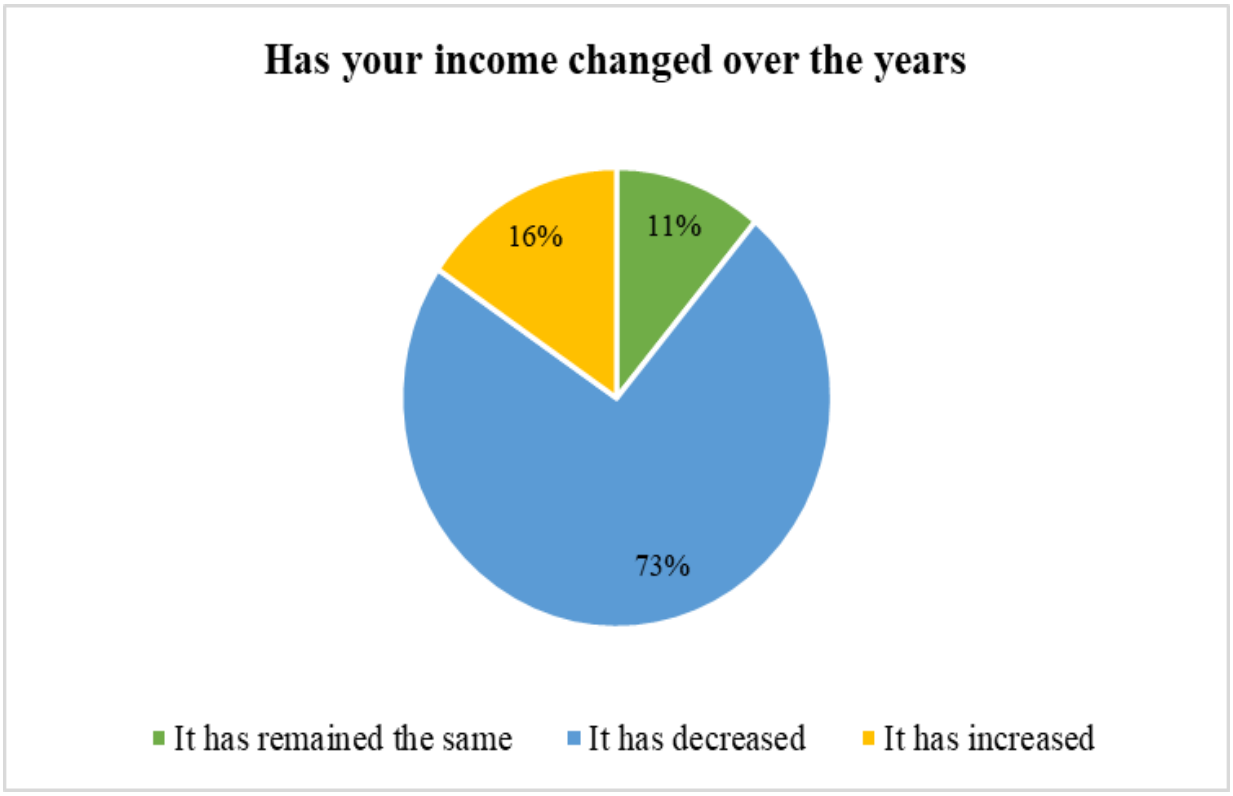

Figure 4.13. Whether the income of the value chain actors has changed over the years

4.3.2 Access to weather information by the fish value chain actors

All respondents claimed that they can access weather information (figure 4.14). The most common source of weather information is the media, through radio stations. Some respondents can use the weather application on their phones to determine the weather of the day.

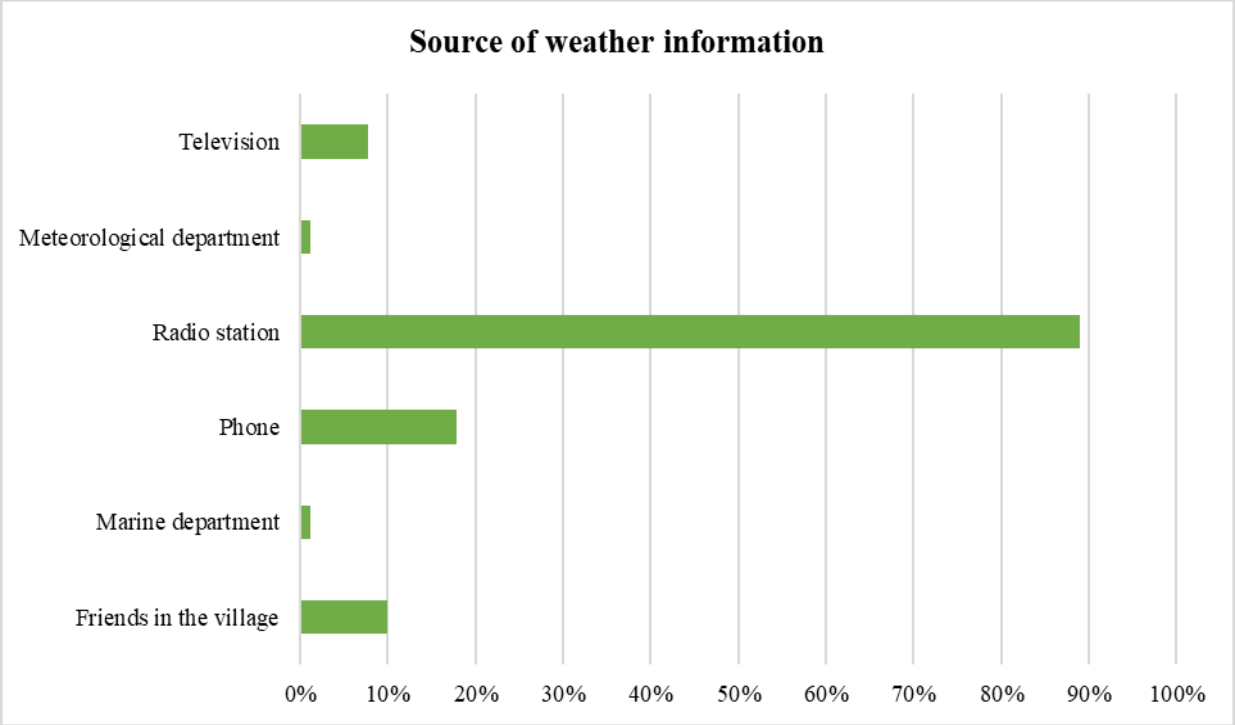

Figure 4.14. common sources of weather information by the respondents

When it comes to opportunities for accessing weather information, a higher percentage of the male and female respondents said that men have more opportunities to access weather information than women, followed by a percentage of respondents that claimed that both men and women have the same opportunities in accessing weather information (figure 4.15). The common reason given is that since it is the men who are involved in fishing activities, they require weather information as a safety precaution before they go fishing. It was also noted that as household heads, men have more control over gadgets and more ability to own them. This makes it easier for them to access weather information than their female counterparts.

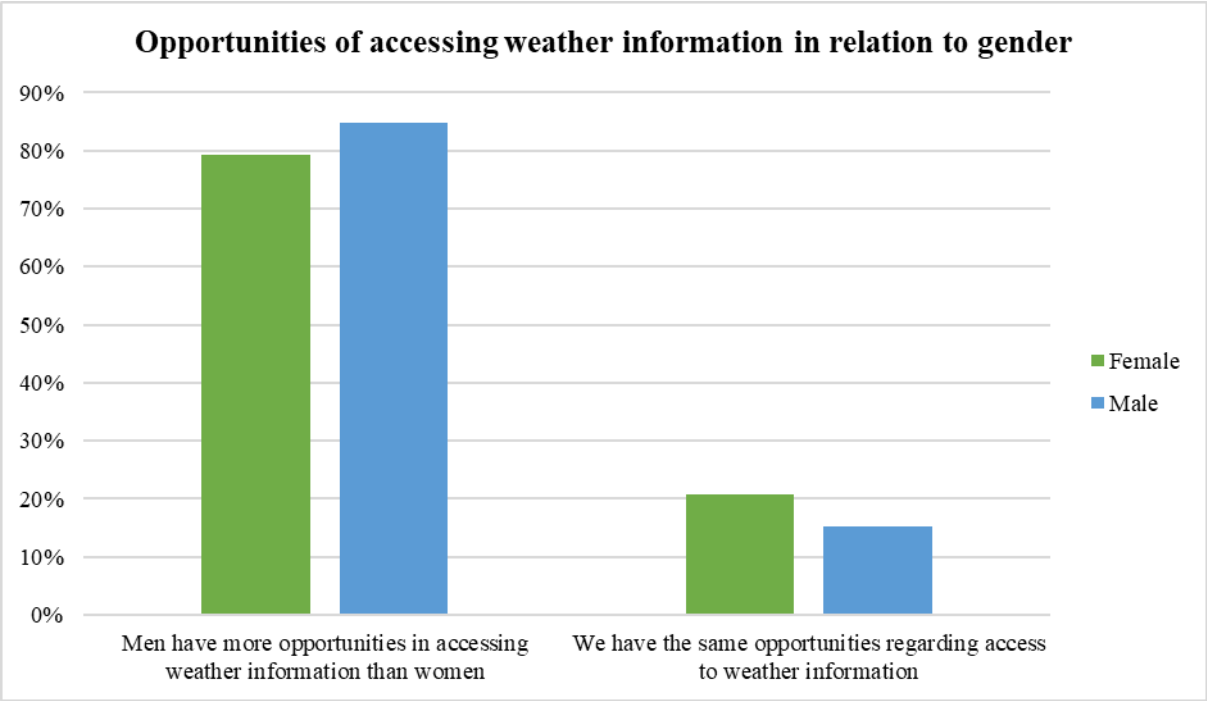

Figure 4.15 opportunities of accessing weather information in relation to gender.

4.3.3 Knowledge of traditional methods of predicting extreme weather events

Results show that 80.3% of male respondents and 75% of the female respondents claim to know some traditional methods of predicting weather events. The rest, 19.7% of males and 25% females do not know and have never heard about any traditional methods of predicting extreme weather events (figure 4.16).

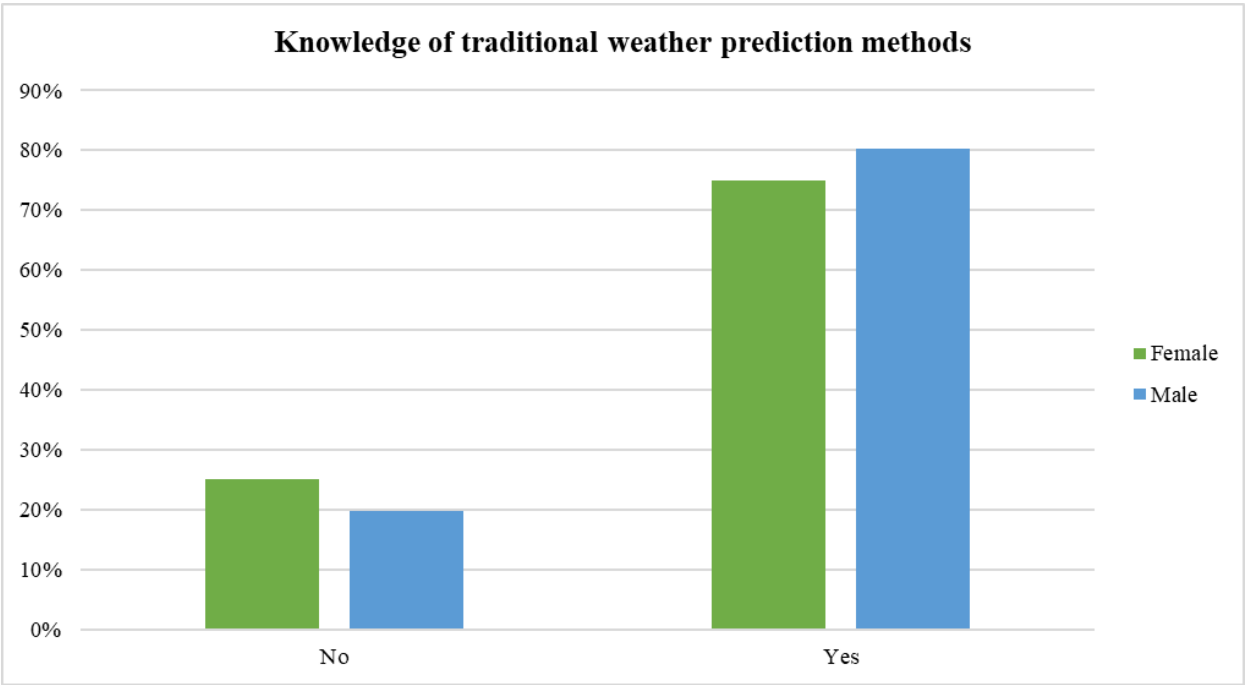

Figure 4.16. Knowledge of traditional methods of predicting extreme weather segregated by gender.

In the table 4.1 below, we can see the type of extreme weather events and how they are predicted as mentioned by the respondents:

Table 4.1. Indigenous/traditional methods of forecasting extreme weather

Weather event	**Sign**
General bad weather	Emergence of some types of insects in trees
North-easterly winds (Mpoto)	Appearance of thick dark clouds in the sky from the north
	Appearance of lake flies
	Steamy hot air
	Air breeze that is very smelly
	Changes in water colour of the lake
South-easterly winds (Mwera)	Low body temperatures in some individuals
	Hernia in some individuals
	Thick dark cloud movement from the south to north
	Formation of foam in the lake
	Stars flashing in the sky
	Abdominal pains in some individuals
	Extreme cold weather
Stormy rains	Dark clouds in the sky
	Lightening
	Upwelling of the waters
	Strong wind movement
	Appearance of woodpeckers

In terms of climate change adaptation options, 57% of the respondents said that using boats with engines to fish offshore would help them increase their fishing efforts and therefore increase fish catches, 28% said that using climate resilient fishing processing methods such as solar drying, using less wood for fish smoking would help save the environment and therefore contribute to climate change adaptation. See figure 4.17 below.

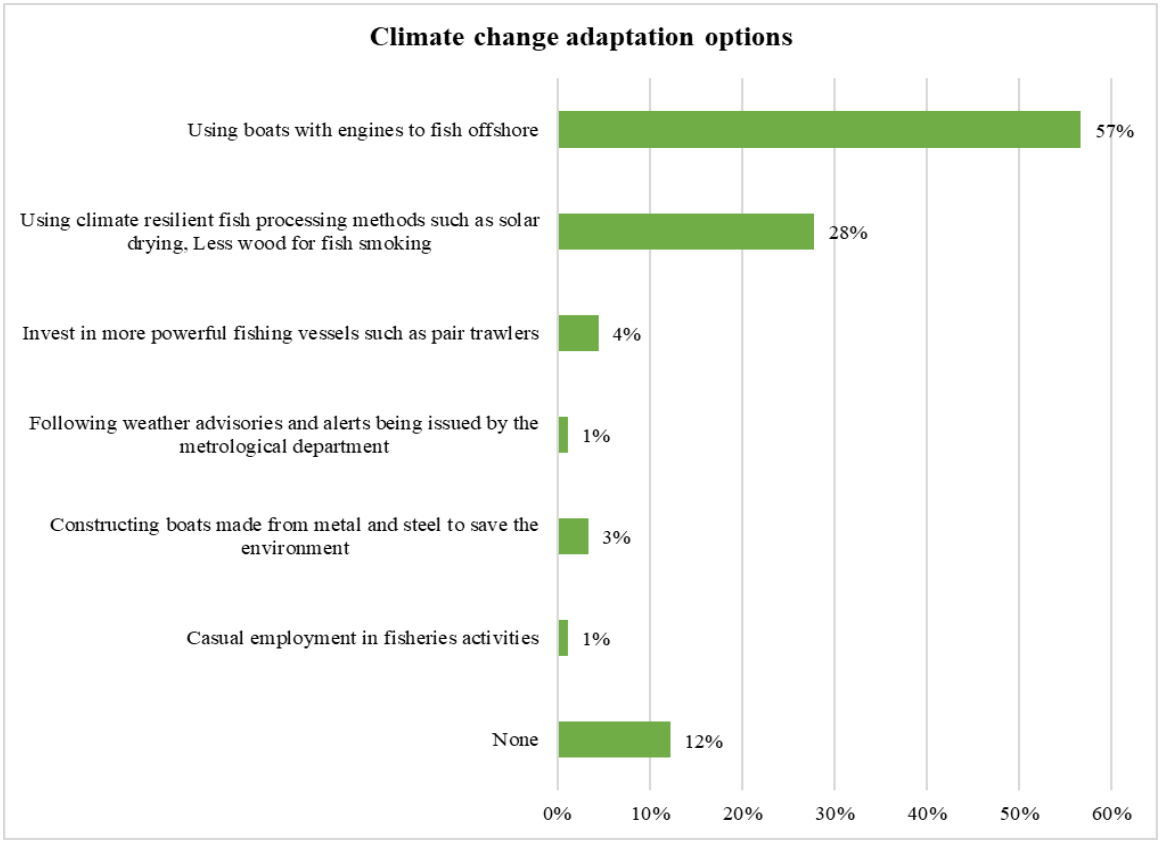

Figure 4.17. Climate change adaptation options as mentioned by the fish value chain actors.

4.3.4 Access to extension services

In terms of fisheries extension services, 59% of the males and 54% of the females claimed to have accessed fisheries extension services over the past year, while 41% of the males and 46% of the females said they did not have access to any fisheries extension services.

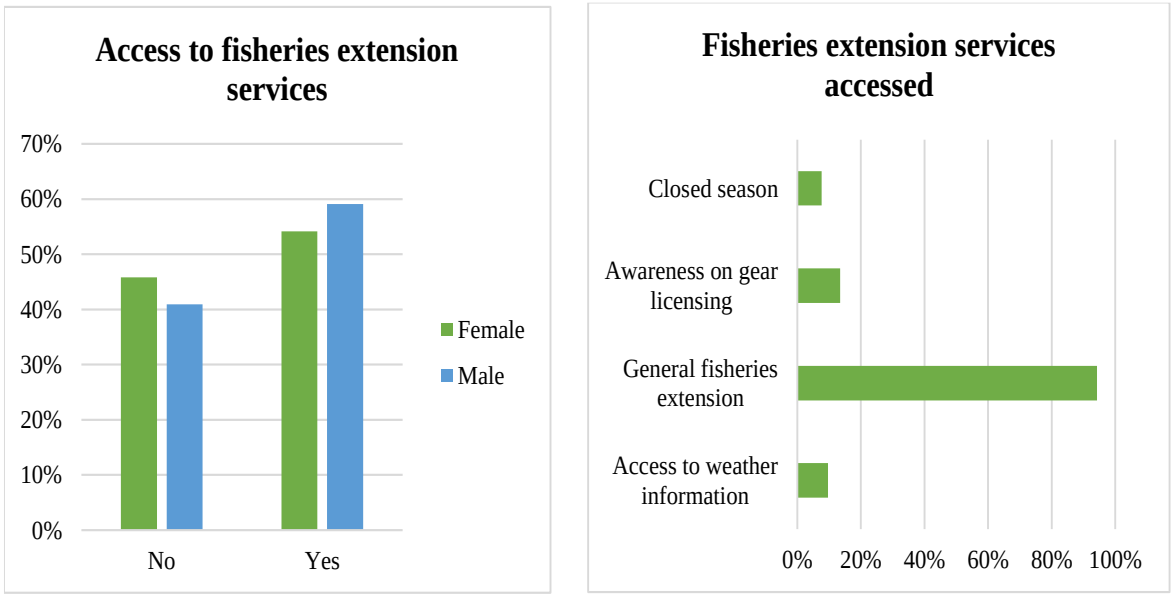

Figure 4.18. Access to fisheries extension services segregated by gender (left) and the type of extension service accessed (right).

In terms of interventions from Non-Governmental Organisations (NGOs), 79% of the females and 74% of the males claimed to not have any access to such interventions while 21% of the females and 26% of the males claimed to have accessed them. The most common intervention was ecosystem management (50%), and other interventions mentioned were wildlife conservation and weather information access (figure 4.19).

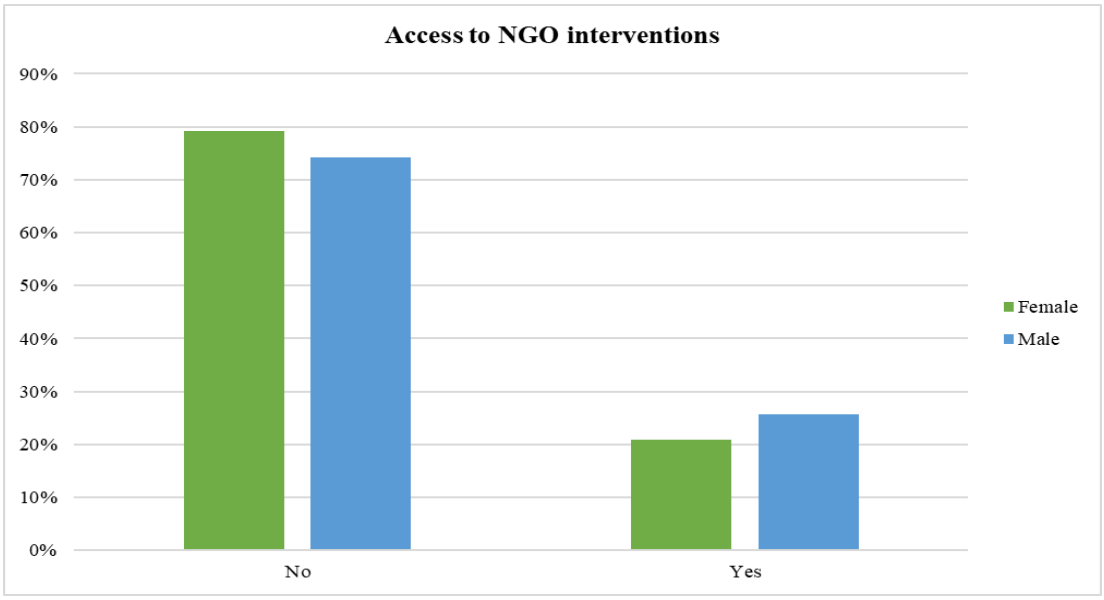

Figure 4.19. Access to Non-Governmental Organization interventions segregated by gender.

5 DISCUSSION

5.1 Composition of the fish value chain in terms of gender and its relationship to the study

Results in figure 4.1 show that out of the total respondents, 76% were males and 24% were female. Studies have shown that men are the primary actors in the fish value chain, with almost 70% of them being involved in fishing activities. The females however are mostly involved in the secondary side of the fish value chain such as fish processing and fish trading (Cheke, 2012). This is in line with a fish value chain study which was conducted at Kachulu and Msaka landing sites on Lake Malawi, where over 95% of the gear owners were men with all the fishing out on the lake being undertaken by crew members who are also men. These fishers then sell their catch to local processors or traders as soon as it is landed on the beach. Women mostly play the role of an intermediary between the other fish value chain actors, fish processing and trading and their representation was estimated to be around 70 to 90% in the three value chains mentioned (Manyungwa-Pasani, et al., 2017). Similarly in Nigeria, women constitute a greater percentage of the fish mongers/processors, representing the first segment of the fish market chain; buying fresh fish directly from the producers/ fishermen as they land the fish at shores (Cheke, 2012).

According to UN Women (2022), it is important to remember that in rural settings where the population is heavily dependent on natural resources for their livelihoods, women are not only vulnerable to climate change, but they are also effective actors or agents of change in relation to both mitigation and adaptation. In Malawian culture, which is highly patriarchal, gender inequalities are persistently putting most women in a position of vulnerability to climate change and variability. The situation is exacerbated when women are heading households (Henriksson, et al., 2021). Women therefore are at a greater risk of experiencing negative impacts of climate change and even greater barriers to adapt to the situation. To achieve food and nutrition security, access to climate and weather information, which have been identified as a potential enabler for improved adaptation should therefore not segregate any gender (Habtezion, 2013). Women usually have a strong body of knowledge and expertise that can be used in climate change adaptation and mitigation, and since women are involved in gendered responsibilities in their households and communities, as stewards of natural and household resources, it positions them well to contribute to livelihood strategies adapted to changing environmental realities (UN Women, 2022).

5.2 The effect of climate change on the livelihoods of the fishing communities in Nkhotakota District

5.2.1 Knowledge and awareness about climate change information in relation to gender

From their responses, the majority of the participants have perceived changes in weather events, including droughts, floods, changes in time of rainfall, which usually comes later in the rainy season than before, and is also erratic. A higher percentage of the male respondents claimed to have some or good knowledge about climate change than the corresponding percentage of their female counterparts. However, when it comes to awareness of climate change issues, women claimed they have some or good awareness of what is happening around them in terms of weather events. When fishers were asked about their perception about climate change in Lake Kariba, they described climate change as the changes in weather outlook, decreasing rainfall, increased occurrence of severe weather events and increasing number of hot days (Muringai, et al., 2019). This affirms that the value chain actors are aware

that weather patterns are changing. Another study in Ghana reported that 92% of fishermen are aware of climate change, but have inadequate adaptation techniques, emphasizing that creating effective climate responses at the local level is crucial. The fishers are aware of rising patterns in air temperature, seawater temperature, interior precipitation, offshore precipitation, and storms. It is therefore important to identify appropriate adaptation strategies for the small-scale fishery.

In a follow-up study on climate change awareness in Cambodia, it was noted that women are the most vulnerable to the impacts of climate change because they normally gain more burdens than men in housework such as taking care of children, cooking, washing, collecting water and firewood, while they are being involved in other activities to earn income (Save Cambodian Wildlife, 2012). The Malawi National Climate Change Policy states that climate change has also exacerbated systemic inequalities between women and men, given that they experience climate impacts differently based on their capacities and vulnerabilities (Government of Malawi, 2016). Similarly at local level, women are often more vulnerable to climate change and variability as observed among sugarcane farmers in the Southern part of Malawi (Henriksson, et al., 2021). Access to climate information, such as weather forecasts, have been identified as a potential enabler for improved adaptation, but such issues tend to be strongly gendered (Henriksson, et al., 2021). This emphasizes the need to bridge the gendered knowledge gap that exists to build a resilient society.

5.2.2 Implication of extreme weather events that have been experienced over the years in Nkhotakota District.

Reports show that as a natural resources' dependent economy, Malawi is vulnerable to any changes of weather events and climate variability due to its high exposure and low adaptive capacity; and it is highlighted as one of the most vulnerable countries in the world to the effects of climate change (Warnatzsch & Reay, 2019). Results from figures 4.6 to 4.8 show that since the 2000s, extreme weather events have become frequent, and pose a threat to livelihoods of fishing communities in one way or another as described by the respondents. This is in line with (Makwinja & M'balaka, 2017), who stated that changes in rainfall season, pattern and temperature, and changes in the frequency of droughts and floods and significant variations in Lake Malawi and river levels have been observed over the years and they are an evidence of climate change in Malawi. Climate change is a long-term phenomenon and will continue to negatively affect the structure and function of natural ecosystems, including the provision of natural services such as fisheries (Makwinja & M'balaka, 2017).

5.2.3 Climate change impacts on inland fisheries as described by the respondents

The respondents mentioned several impacts of the climate related extreme weather events, as highlighted in figures 4.9 to 4.12. Some of the impacts highlighted include low fish catches, changes in fishing grounds, upgrading fishing gears and catching different fish species than before due to scarcity of fish.

According to Allison, et al., (2005), inland fisheries will be impacted by climate change through a series of direct and indirect pathways, whose relevance will vary depending on the type of ecosystem and fishery. It has been reported that climate change has begun to affect freshwater ecosystems as reported for the surface waters of Lakes Kariba, Kivu, Tanganyika, Victoria and Malawi (Niang, et al., 2014). It was also observed that the moderate warming would contribute to reduced lake water inflows and therefore nutrients, which subsequently destabilizes plankton dynamics and thereby adversely affects food resources for higher trophic levels of mainly planktivorous fish (also refer to section 2.2). As an integral part of the livelihood of the small-scale fishers, the fishery will be affected through changes in water

levels and flooding events, temperature and increased frequency of extreme weather events which will affect the number of fishing days and therefore the income of the fish value chain players (Deepananda & Macusi, 2012), also refer to section 2.4. Similarly, although interacting drivers of fisheries decline in African lakes are uncertain, given the extent to which other factors, such as increased effort, the use of illegal gears, pollution, and invasive species among others, climate change should not be ruled out in this narrative (Allison, et al., 2005; Muringai, et al., 2019).

Changes in fish habitats due to physical water parameter changes would have an impact on fish abundance and distribution over time as evidenced in Lake Kariba and Lake Tanganyika (IPCC, 2014; Muringai, et al, 2021), as described in section 5.2.2 above. It has also been reported that two thirds of climate change vulnerability in fisheries is in Africa, with a 21% projected loss in fish catches, 50% decline in fisheries-related employment and a total annual loss of US$311 million to the region's economy (Niang, et al., 2014).

5.2.4 Coping and adaptation mechanisms identified during the study

In reference to figure 4.13 on the income of the fishers over the years, 73% of the respondents reported a decline in their income, which was mostly attributed to low fish catches; 36% of the respondents were sorely dependent on fisheries activities as their source of income, while 52% of the respondents are also involved in rainfed farming, which is also vulnerable to climate change shocks. As a coping mechanism, the majority of the respondents said they would use boats with engines to catch more fish offshore and by using climate resilient fish processing methods such as solar drying, fuel efficient fish smocking methods. Fishers are likely to use illegal and destructive illegal fishing gears as a way of adapting to low fish catches as reported by (Huynh, et. al., 2020; Limuwa, et. al, 2018).

The responses from the participants are also in line with the analysis of poverty in small-scale fisheries with guidance by the sustainable livelihoods analytical framework which identified vulnerability to external shocks and trends, rather than asset or income poverty, as a particular threat to the sustainability of fishing-based livelihoods (Allison, et al., 2005). This would undermine important contributions made by fisheries to poverty alleviation and nutritional security at local, regional and sometimes national levels. There is also a suggestion that climate change may impact fisheries in at least two different ways: by altering the availability of fish to fishermen (direct impact) and by changing the price of fish products and fisheries inputs (indirect impact). (Daw, et. al, 2009) reported that the poverty of many fishing communities has been derived endogenously from the inevitable overexploitation and poor returns from open-access resources (people are poor because they are fishers); or exogenously because the influx of the poorest of the poor into fisheries as a last resort (they are fishers because they are poor), which is in line with the responses of the coping mechanisms from the respondents. From this analysis, it can be said that climate change poses threats not only to fisheries and fish productivity but also to livelihoods and food security of fishery dependent households in Malawi (Muringai, et al, 2019).

The adaptation strategies employed by the respondents as outlined in figure 4.17 are also in line with (Muringai, et al, 2021), who stated that to cope with the impacts of climate change, fishers considered changing fishing gear, migration, targeting new species, and increasing fishing grounds and time spent fishing. Some of the adaptation responses have potentially negative long-term consequences if overexploitation is a concern in the fishery (Daw, et al., 2009).

5.3 Climate change adaptation options for inland fisheries of Lake Malawi

Fisheries resources face many uncertainties and multiple potential pathways which link climate change with fisheries production (FAO, 2020). Lake Malawi fishery has been further compounded by a series of anthropological factors, which affect the socio-economic capacity of the sector. It is therefore important to understand the impacts of climate change on livelihoods and the resulting vulnerability of fisherfolk is essential for the appropriate design of policies and management strategies in the fisheries sector (Allison, et al., 2005).

It has been noted that even at global level, the implementation of climate-adaptive measures in fisheries management has been slow, with many challenges to document their effectiveness and benefits (Deepananda & Macusi, 2012). It has also been suggested that climate change adaptation measures should not only focus on responses to extreme weather events, but rather on all changes that happen within the system (Bahri, et al., 2021). Climate change adaptation should be considered at individual, community, national, or regional level. (Niang, et al., 2014) stated that Africa has adaptation-related strengths because the continent is rich in natural resources, which are underpinned by local or indigenous knowledge systems for sustainable resource management.

Several possible climate change adaptation options are outlined below:

5.3.1 Access to weather information should be enhanced

Natural resources dependent livelihoods such as fishing activities are very risky due to extreme weather events and climate shocks. The respondents outlined in figures 4.6 to 4.8 that the extreme weather events, such as Southeasterly (Mwera) winds have become more common and could even lead to loss of life if not monitored. It has been reported that extreme events such as cyclones and their associated storm surges and inland flooding can have serious impacts on fisheries, through damage or loss of stock, facilities and infrastructure and even loss of lives (Tewabe, 2015). To build resilience and adaptive capacity of fish value chain actors, it is important to examine the responses of fishing communities to natural disasters across all genders to understand which measures may reduce vulnerability and enhance resilience in the face of future climate impacts (IPCC, 2014). In this regard, access to weather information should be promoted to reduce avoidable weather-related accidents and contribute to long-term disaster risk management planning (Rota & Abila, 2015).

The Green Climate Fund together with the UNDP has taken the first step in scaling up climate information and early warning systems to the fishers through capacity building and provision of weather information in Malawi (Gerdvila, 2021). In Senegal, it has been observed that if weather forecasts were made accessible to most fisher-folks, more than 83% would avoid going to sea during periods of extreme weather extreme events, thus significantly reducing the number of fatalities (Diouf, et al., 2020). Accurate weather forecasts would therefore help the fishers overcome the negative impacts of extreme weather events. It is therefore important to ensure that these efforts are upscaled to reach all fishing communities and that they are adopted through policy to ensure there is sustainability.

5.3.2 Inclusion of climate change information in fisheries extension messages

Figures 4.18 and 4.19 in the results show that most of the respondents were able to access general fisheries extension services and not information on climate change. (IPCC, 2014) states that effective adaptation strategies should strengthen livelihoods, enhance wellbeing and human security, and reduce poverty today. This would be possible through the provision of extension services. It has been noted that making climate change information reliable and accessible is one of the pressing and cross-cutting adaptation needs, but providing information

is insufficient to guarantee adaptation, which requires behavioural change (Niang, et al., 2014). Therefore, climate information should be downscaled together with general extension messages to improve the adoption rate by the fish value chain actors.

5.3.3 Ecosystem approach to fisheries management should take on board climate change and its impacts

Fisheries management systems should take on board climate change adaptation, as predicting freshwater ecosystems and fisheries responses to climate change is uncertain. This begins by describing good practices and the foundational principles of fisheries management in general, which are also central to coping with climate change (Bahri, et al., 2021). Effective fisheries management systems are the ones that consider the internal and external factors in order to foster socio-ecological systems which would provide building blocks for the maintenance of livelihoods in the face of critical and pervasive threats, and resilient fisheries that can absorb disturbances and reorganize themselves following perturbation while still delivering benefits for poverty reduction (Badjeck, et al., 2009). Working towards equitable and sustainable fisheries, should therefore be a goal of fisheries management as a way of advancing the adaptive capacity of fishing communities and this includes climate variability and social aspects of fisheries (Daw, et al., 2009).

There is evidence that climate change increases environmental variation. This would create an additional imperative to implement the ecosystem approach to fisheries (EAF). Adaptation for climate change, in terms of building the resilience of fish stocks and communities and taking account of uncertainty, could therefore be seen as implementation of good fisheries governance (Deepananda & Macusi, 2012). Thus, adaptation for climate change, in terms of building the resilience of fish stocks and communities and taking account of uncertainty, could be seen as implementation of good fisheries governance to assist adaptation (Daw, et al., 2009).

5.3.4 Formulation of fisheries climate change strategies to guide climate financing in the fisheries sector

According to (Bahri, et al., 2021), having a robust adaptive management framework to guide fisheries managers and stakeholders to test, evaluate, review and adjust decisions based upon monitoring or observations of changing fishery, climatic and environmental conditions is essential to improving climate readiness in the fishery management cycle. (Niang, et al., 2014) observed that across the continent, most of the adaptation to climate variability and change is in response to short-term motivations and is occurring autonomously at the individual/household level and lacks support from government stakeholders and policies. There is a need to develop long term strategies for climate change adaptation for the fisheries sector. This would also act as a guiding principle when it comes to climate change financing. (Limuwa, et al., 2018) suggested the need to mainstream adaptation into development policies which might strengthen the adaptive capacity of small-scale fishers. Though adaptation is a difficult process when coupled with a declining fish population, solutions to enhance adaptation may be identified if the local system is understood.

Existing knowledge and solutions, lessons learnt and good practices for developing climate-adaptive fisheries management for Lake Malawi should be adopted. Lessons may include existing adaptation strategies that are being used in other inland fisheries which share similar characteristics to Lake Malawi. The developed policies and strategies should promote opportunities for livelihood diversification, to ease pressure on the fishery as overfishing is one of the driving factors to a decline in fish catches (Huynh, et al., 2020). The policies and

strategies should not disregard or undermine cultural and traditional and context-specific practices that aid climate adaptation (IPCC, 2014).

5.3.5 Infusion of indigenous and modern knowledge to create a clear understanding on adaptation and mitigation

Results in figure 4.16 show that most of the respondents claimed to have some indigenous or traditional knowledge in weather prediction. Table 2.1 shows some of the extreme events and how they are predicted traditionally. It is believed that local knowledge is an important aspect of rural communities, and it is handed down from generation to generation (Kpadonou, et al., 2012). Incorporating indigenous knowledge which is grounded on traditions and culture, community priorities, needs, and capacities, will enable local people to plan and cope with the impact of environmental change in fisheries and other sectors. Combining local and scientific knowledge in weather forecasting is known to be important component of the concept of ethno-meteorology. It is based on traditional ecological knowledge handed down from generation to generation (Tume, et al., 2019). According to IPCC (2014), local and indigenous knowledge underpin longstanding traditional practices for managing climate variability. Local leaders should be involved in climate change adaptation process because they have influence in their communities. It is therefore important to document such indigenous knowledge to enhance its use in local climate change adaptation and utilize synergies with the formal weather forecasting systems.

5.3.6 Institutional capacity building to ensure effective implementation of the formulated strategies

Climate change adaptation should also focus on building the capacity of the fisheries staff to ensure effective and efficient service delivery. (Niang, et al., 2014) stated that climate change adaptation should not underestimate the importance of institutions' ability to facilitate or limit adaptation. Information of climate change in fisheries sector should be incorporated in the curriculum of tertiary institutions. According to (Efitre, et al., 2017), increasing human and institutional capacity to address threats posed by climate change to natural resources and livelihoods requires building capacity to generate and disseminate information and knowledge on climate change, its impacts, adaptation and mitigation through research, education and raising awareness by tertiary training institutions. Staff should also be engaged in capacity building training to improve their knowledge in the subject matter.

5.3.7 Synergy in implementing adaptation measures with other institutions

Climate change adaptation strategies should follow a multisectoral approach. This is because its impacts are likely to cut across sectors as with the other socio-economic and environmental drivers (Badjeck, et al., 2009). It would also create a synergy between climate change and non-climate change drivers which need to be recognized as we are tackling the issue. According to (Bahri, et al., 2021), climate change does not act in isolation but interacts with other drivers, such as pollution, habitat degradation and unsustainable fishing (among others), and these stressors act in a cumulative fashion to disrupt the freshwater ecosystems and the fisheries that depend on them (Niang, et al., 2014). Monitoring and modelling should therefore identify and quantify the contributions of climate change among other drivers of change that are important to inform adaptation targeted at fisheries management, and to identify whether fishing has the dominant effect on the status of a stock. This approach will be vital in identifying various pathways to climate change adaptation in the fisheries sector. (Bahri, et al., 2021) also stated that working in synergy will ensure that management goals and objectives are realistic regarding future conditions and help prioritize management interventions. Implementation of this strategy would also promote livelihood diversification

opportunities and address household-level constraints for adaptation. This would ease the pressure exerted on fisheries resources (Huynh, et al., 2020).

5.3.8 Inclusion of gender mainstreaming in climate change adaptation

With reference to section 5.1, it is important to recognize the significance of equity across gender, age, and income in addressing climate change in the fisheries sector; and how adaptation measures can support and enhance equity (Bahri, et al., 2021). Inclusion of women in adaptation will enhance the capacities of the systems in addressing some of the climate change shocks, as women play a big role in their societies. It has also been noted that sustainable development and equity provides a basis for assessing climate policies and addressing the risks of climate change (IPCC, 2014). Climate change adaptation programs should be gender-sensitive and capable of measuring progress and achievements toward addressing gender inequities and having effective, efficient, equitable and sustainable climate action at the same time. Gender dimensions should be integrated in all aspects to ensure that women are involved at all levels.

6 CONCLUSION

From various literature reviews and the interviews conducted in the study, it can be concluded that climate change is affecting the inland fisheries of lake Malawi. There isn't enough literature and evidence to show the impacts of climate change on inland fisheries, even though marine fisheries resources have received a lot of attention. Climate change impacts on the fisheries resources are different, depending on the structure of the water body, geographical position and how vulnerable the country is to extreme weather events. Over the last few decades, Malawi has experienced climate related disasters ranging from floods, droughts, and heavy winds, which could also have a negative impact on the livelihoods on the fishing communities.

It is very difficult to isolate the impacts of climate change on Lake Malawi due to other factors such as dwindling fish catches due to overfishing, the use of illegal fishing gears, the open access nature of the fishery among others. Climate change adaptation should therefore be incorporated in the management of Lake Malawi ecosystem. There is lack of consistent time series data on most of the parameters that would be necessary to quantify the effect of climate change on inland fisheries of Lake Malawi.

Even though the number of respondents in the study was limited, it can still be said that fish value chain actors are aware about what is happening around them in terms of changes in weather and are able to use their indigenous knowledge to adapt to some of the negative impacts. It is important to build the adaptive capacity of the fishing communities to ensure that they cope with climate induced stress. Most of the fishing communities are solely dependent on the fishery resource for their livelihood and do not have any other livelihood option. Most of those that have are involved in rainfed farming, which is also vulnerable to climate-induced shocks.

7 RECOMMENDATIONS

The following are some of the recommendations that have been deduced from the study:

- Climate change adaptation and mitigation should consider taking a gendered approach to avoid maladaptation.
- There should be a multisectoral approach to climate change adaption, to ensure that all components of natural resources are taken into consideration.
- Climate change information and early warning systems should be readily available to the fishing communities.
- The fisheries sector should come up with a climate change strategy to inform implementation of climate change activities in the sector.
- Structures to collect time series data on important parameters such as temperature and other water related parameters should be deliberately put in place and monitored to ensure climate change related issues are documented.

8 REFERENCES

Allison, E. H., Adger, W. N., Badjeck, M.-C., Brown, K., Conway, D., Dulvy, N. K., . . . Reynolds, J. D. (2005). *Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisherfolk living in poverty project* . London: Fisheries Management Science Programme.

Arndt, C., Schlosserb, A., Strzepekb, K., & Thurlowc, J. (2014). Climate change and economic growth prospects for Malawi: An uncertainty approach. *Journal of African Economies, Vol 23*, 83-107.

Arthur, R., Skerritt, D. J., Schuhbauer, A., Ebrahim, N., Friend, R. M., & Sumaila, U. R. (2021). Small-scale fisheries and local food systems: transformations, threats and opportunities. *Fish and Fisheries*.

Badjeck, M.-C., Allison, E. A., Halls, A. S., & Dulvy, N. K. (2009). Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 375-384.

Bahri, T., Vasconcellos, M., Welch, D., Johnson, J., Perry, R., Ma, X., & Sharma, R. (Eds.). (2021). Adaptive management of fisheries in response to climate change. *FAO Fisheries and Aquaculture Technical Paper No. 667*.

Bhave, A. G., Bulcock, L., Dessai, S., Conwaye, D., Jewitt, G., Dougill, A. J., . . . Mkwambisi, D. (2020). Lake Malawi's threshold behaviour: A stakeholder-informed model to simulate sensitivity to climate change. *Journal of hydrology*, 1-11.

Cheke, A. (2012). Women in Fish Value Chain in Nigeria. *16th Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET 2012 Tanzania)* (pp. 1179-1184). Printed by Curran Associates, Inc.

Conway, D., Allison, E., Felstead, R., & Goulden, M. (2005). Rainfall variablility in East Africa: implications for natural resources management and livelihoods. *Philosophical Transactions of the Royal Society*, 49-54.

Daw, T., Adger, W., Brown, K., & Badjeck, M. (2009). Climate change and capture fisheries: potential impacts, adaptation and mitigation. (C. D. K. Cochraine, Ed.) *Climate change implications for fisheries and aquaculture: Overview of current scientific knowledge*, pp. 107-150.

Deepananda , A. K., & Macusi, E. D. (2012). The changing climate and its implications to capture fisheries: A review. *Journal of Nature Studies 11 (1&2): 71-87*, 17.

Diouf, N. S., Ouedraogo, I., Zougmoré, R. B., & Niang, M. (2020). Fishers' perceptions and attitudes toward weather and climate information services for climate change adaptation in Senegal. *Sustainability*, 1-17.

Dudgeon, D. (2012). Threats to freshwater biodiversity globally and in the Indo-Burma Biodiversity Hotspot. *Environmental Science*.

Eckstein, D., Künzel, V., & Schäfer, L. (2021). Who suffers most from extreme weather events? Weather-related loss events in 2019 and 200-2019. (J. Chapman-Rose, & J. Longwitz, Eds.) *Global climate risk index 2021 Briefing paper*, pp. 1-52.

Efitre, J., Natonguza, V., Musungizi, L., Olokotum, M., Naigaga, S., & Ogotu-Ohwayo, R. (2017). Building capacity for climate change mitigation and adaptation through

mainstreaming climate change in curricula of tertiary training institutions in Africa. In W. L. Filho, *Climate change research at universities* (pp. 423-440). Springer international publishing.

FAO. (2018). Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. (M. Barange, T. Bahri, M. C. Beveridge, K. L. Cochrane, S. Funge-Smith, & P. Florence, Eds.) *Fao Fosheries and Aquaculture Technical Paper 627*.

FAO. (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in action.* Rome: Food and Agriculture Organisation of the United Nations. doi:https://doi.org/10.4060/ca9229en

Funge-Smith, S., & Bennet, A. (2019). A fresh look at inland fisheries and their role in food security and livelohoods. *Fish anf fisheries* , 1176-1195.

Gerdvila, S. (2021). *Protecting Malawi with climate information and early warning systems.* Retrieved from Reliefweb: https://reliefweb.int/report/malawi/protecting-malawi-climate-information-and-early-warning-systems

Government of Malawi. (2015). *Overcoming poverty in Malawi through sustainable environment and natural resource management: Identifying policy options to accelerate poverty reduction.* Lilongwe: Poverty Environment Action, UNDP.

Government of Malawi. (2016). *National Climate Change Policy.* Lilongwe: Ministry of Forestry and Natural Resources.

Government of Malawi. (2016). *National Fisheries and Aquaculture Policy.* Lilongwe: Department of Fisheries.

Government of Malawi. (2019). *Malawi-climate resilient and sustainable capture sheries, aquaculture development and watershed management project.* Retrieved from Global Environment Facility (GEF) Operations: https://www.thegef.org/sites/default/files/web-documents/10411_CCA_PIF.pdf

Government of Malawi. (2020). *Malawi's National Adaptation Plan Framework.* Lilongwe: Ministry of Forestry and Natural Resources.

Habtezion, S. (2013). *Gender and disaster risk reduction.* New York: United Nations Development Programme .

Hara, M. (2011). Community response: Decline of the Chambo in lake Malawi's Southeast Arm. *Researchgate*, 24.

Heck, S., Bene, C., & Reyes-Gaskin, R. (2007). Investing in African fisheries: Building links to the Millenium Development Goals. *Fish amd Fisheries*, 211-226. doi:https://doi.org/10.1111/j.1467-2679.2007.00251.x

Henriksson, R., Vincent, K., Archer, E., & Jewitt, G. (2021). Understanding gender differences in availability, accessibility and use of climate information among smallholder farmers in Malawi. *Climate and Development*, 503-514.

Huynh, P. T., Le, N. D., Le, S. T., & Tran, T. N. (2020). Adaptive livelihood strategies among small-scale fishing households to climate change related stressors in Central Coast Vietnam. *Journal of Climate Change Strategies and Management, 13*(4/5), 492-510.

IFPRI/RMSI. (2010). *Malawi: Economic Vulnerability and Disaster Risk Assessment. Economy-Wide Impacts of Droughts and Floods.*

IPCC. (2014). *The Intergovernmental Panel on Climate Change Fifth Assessment Report. What's in it for Africa?* Geneva, Switzerland: IPCC.

IPCC. (2014). *The Intergovernmental Panel on Climate Change Fifth Assessment Report. What's in it for Africa?* Geneva, Switzerland: IPCC.

Kao, Y.-C., Rogers, M. W., Bunnell, D. B., Cowx, I. G., Qian, S. S., Anneville, O., . . . Young, J. D. (2020). Effects of climate and land-use changes on fish catches across lakes at a global scale. *Nature communications*, 14. doi:doi.org/10.1038/s41467-020-14624-2

Kassam, D., Changadeya, W., Stima, H., Jere, W., & Kaunda, E. (2017). Morphological and genetic variability among Mpasa (Opsaridium microlepis, Ganther, 1864). *International Journal of Fisheries and Aquaculture*, 52-58.

Kaunda, P. (2016). *Investigating the impacts of climate change on the levels of Lake Malawi.* Nairobi: University of Nairobi.

Kpadonou, R., Adégbola, P., & Tovignan, S. (2012). Local knowledge and adaptation to climate change in Ouémé Valley, Benin. *African Crop Science Journal*, 181-192.

Kumambala, P. G., & Ervine, A. (2010). Water balance model of Lake Malawi and its sensitivity to climate change. *The Open Hydrology Journal*, 152-162.

Limuwa, M. M., Sitaula, B. K., Njaya, F., & Storebakken, T. (2018). Evaluation of small-scale fishers' perceptions on climate change and their coping strategies: Insights from Lake Malawi. *Climate*, 1-23.

Loring, P. A., Fazzino, D. V., Agapito, M., Chuenpagdee, R., Gannon, G., & Isaacs, M. (2019). Fish and food security in small-scale fisheries. In R. Chuenpangdee, & S. Jentoft (Ed.), *Transdisciplinarity for small-scale fisheries governance. 21*, p. 319. Springer, Cham: MARE Publication Series.

Lowe, B. S., Jacobson, S. K., Anold, H., Mbonde, A. S., & O'Reilly, C. M. (2019). Adapting to change in inland fisheries: analysis from Lake Tanganyika, East Africa. *Regional Environmental Change*, 1765-1776.

Makwinja, R., & M'balaka, M. (2017). Potential impact of climate change on Lake Malawi. *Journal of Ecosystem & Ecography*.

Malawi Government. (2021). *Annual Economic Report 2021*. Lilongwe: Ministry of Economic Planning & Development and Public Sector Reforms.

Manyungwa-Pasani, C. L., Hara, M., & Chimatiro, S. K. (2017). Women's participation in fish value chains and value chain governance in Malawi: A case study of Msaka (Lake Malawi) and Kachulu (Lake Chilwa). *Working Paper 45. PLAAS, UWC: Cape Town.*, 1-31.

M'balaka, M., Kanyerere, G., & Kawonga, D. (2018). Assessment of artisanl Chambo fisheries in Mangochi. *International Journal of Fisheries and Aquatic Studies*, 6.

McSweeny, C., New, M., & Liczano, D. (2012). *UNDP Climate Change Country Profiles.* New York: UNDP.

Ministry of Forestry and Natural Resources . (2021). *The Third National Communication of the Republic of Malawi to the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).* Lilongwe: Republic of Malawi.

MoIWD. (2015). *Annual water resources situation report.* Lilongwe: Ministry of Irrigation and Water Development.

Muringai, R. T., Mafongoya, P. L., & Lottering, R. (2021). Climate change and variability impacts on Sub-Saharan African Fisheries: A review. *Reviews in Fisheries Science and Aquacuture*.

Muringai, R. T., Naidoo, D., Mafongoya, P., & Sibanda, M. (2019). Small-scale fishers' perceptions of climate change and its consequencies on fisheries: the case of Sanyathi fishing basin, Lake kariba, Zimbabwe. *Transactions of the Royal Society of South Africa*, 248-257. doi:10.1080/0035919X.2019.1639564

Niang, I., Ruppel, I., Abdrabo, M., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). *Change 2014: Impacts, Adaptation and Vulnerability. Part B: Region Asects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Njaya, F. (2018). Ecosystem approach to fisheries in southern Lake Malawi: Status of the fisheries co-management. *Aquatic Ecosystem Health & Management*, 159–167.

Pauw, K., Thurlow, J., & van Sevente, D. (2010, April). Droughts and Floods in Malawi: Assessing the economywide effects. *IFPRI Discussion Paper*, p. 44.

Powers, L. A., Johnson, T. C., Werne, J. P., Castañeda, I. S., Hopmans, E. C., Sinninghe Damsté, J. S., & Schouten, S. (2011). Organic geochemical records of environmentally variability in lake Malawi during the last 700 years, Part I: The TEX86 temperature record. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 133-139.

Republic of Malawi. (2011). *The Second National Communication of the Republic of Malawi to the Conference of Parties (COP) of the United Nations Framework Convention of Climate Change (UNFCCC).* Lilongwe: Ministry of Natural Resources, Energy and Environment.

Rota, A., & Abila, R. (2015). How to do Fisheries, aquaculture and climate change. Guidance for adaptation and mitigation. *How to do Notes, Environment and climate change*, pp. 1-36.

Salifu, I. (2021). A review of climate change perception and adaptation strategies among fisher-folks. *Academia Letters*.

Save Cambodian Wildlife. (2012). *Assessment report on awareness and knowledge level on climate change and adaptation practices.* Cambodia: UND-PGEF.

Seggel , A., & De Young , C. (2016). *Climate change implications for fisheries and aquaculture: Summary of the findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report.* Rome: FAO.

Sowman, M., & Cardoso, P. (2010). Small-scale fisheries and food security strategies in countries in the Benguela Current Large Marine Ecosystem (BCLME) region: Angola, Namibia and Sounth Africa. *Marine Policy*, 1163-1170. doi:https://doi.org/10.1016/j.marpol.2010.03.016

Tewabe, D. (2015). Climate Change Challenges on Fisheries and Aquaculture. *International Journal of Aquaculture and Fishery Science*, 6-11.

Tume, S. J., Kimengsi, J. N., & Fogwe, Z. N. (2019). Indigenous knowledge and farmer perceptions of climate and ecological changes in Bameda Highlands of Cameroon: Insights from the Bui Plateau. *Climate*, 1-18.

UN Women. (2022, 02 07). *Women, Gender Equality and Climate Change.* Retrieved from http://www.un.org/womenwatch/feature/climate_change/: http://www.un.org/womenwatch/feature/climate_change/

USAID. (2021, November 26). *Climate change risk profile Malawi*. Retrieved from Climate links: https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20profile%20-%20Malawi.pdf

Utete, B., Phiri, C., Mlambo, S. S., Muboko, N., & Fregene, B. T. (2018). Fish catches and the influence of climatic and non-climatic factors in Lakes Chivero and Manyane, Zimbabwe. *Congent Food and Agriculture*, 1-12.

Vollmer, M., Bootsma, H., Hecky, R., Patterson, G., Halfman, J., Edmond, J., . . . Weiss, R. (2005). Deep-water warming trend in Lake Malawi, East Africa. *Limnology and Oceanography*, 727-732.

Warnatzsch, E. A., & Reay, D. S. (2019). Temperature and precipitation change in Malawi: Evaluation of CORDEX-Africa climate simulations for climate change impact assessments and adaptation planning. *Science of the Total Environment*, 378-392.

Weyl, O., Ribbink, A., & Tweddle, D. (2010). Lake Malawi: Fishes, fisheries, biodiversity, health and habitat. *Aquatic Ecosystem Health & Management*, 241-254.

World Meterological Organization. (2022). *State of the Climate in 2021*. Switzerland: WMO.

9 APPENDIX

Questionnaire used to collect primary data

ASSESSING THE IMPACTS OF CLIMATE CHANGE ON INLAND FISHERIES: A CASE STUDY OF LAKE MALAWI

Student: Carolyn Chinguo Munthali

Introduction:
This questionnaire is for a study on "assessing the impacts of climate change on inland fisheries: a case study of Lake Malawi". The questionnaire will be used to compile a research report for GRO–Fisheries Training Programme under the auspices of United Nations Educational, Scientific and Cultural Organisation (UNESCO). The training is a programme under the partnership between Marine and Freshwater Research Institute (MFRI) and the University of Akureyri, Iceland. The programme is aimed at strengthening capacity within fisheries and aquaculture sectors in developing countries including Malawi. The study seeks to investigate how climate change has affected the livelihood of the fishing communities along lake Malawi, specifically in Nkhotakota District. The purpose of this questionnaire is to find out how climate change has affected fish value chain actors and come out with possible adaptation options for the fishery. You will be asked questions regarding your perceptions on climate change and its impacts on fisheries. The interview requires approximately **20 minutes** of your time to be completed.

Participation
Taking part in this questionnaire is a voluntary exercise. The questionnaire and your responses will not be used to your disadvantage. You will be treated with anonymity. As such, the researchers will not attempt to identify you with the responses to this questionnaire, or to name you as having taken part in this research. All responses will be treated with confidentiality and used for research only. You have an option not to answer any question or respond to any part or aspect of this questionnaire.

Interviewer: _____
Name of landing site: _____
Gender of the Interviewee: _____

Section 1: Demographic characteristics

1.1. Age of respondent.
☐ 18-25 ☐ 26-33 ☐ 34-40 ☐ 40-50 ☐Above 50

1.2. Gender of respondent
☐ Male ☐ Female

1.3. Marital status of respondent
☐ Single ☐ Married ☐ Divorced ☐ Widowed ☐ Separated

1.4. Education level of respondent
☐ None ☐ Primary level ☐ Secondary level ☐ Higher level

1.5. Are you the breadwinner in your household? ☐ Yes ☐ No

1.6. What is your household size? ☐ Less than 4 ☐ 5 to 10 ☐ More than 10

1.7. What is your occupation?

☐ Fisher ☐ Trader ☐ Processor ☐ Boat builder

If the answer is fisher, answer *questions **1.8 and 1.9*** then proceed to ***question 1.14***; if it is fish trader, go to ***1.10 and 1.11*** then proceed to ***1.14***, if processor, go to ***question 1.12*** then proceed to question ***1.14***, if boat builder, go to ***question 1.13*** then proceed to the other questions.

1.8. Are you a gear owner or a crew member?

☐ Gear owner ☐ Crew member

1.9. What type of fishing craft do you use for fishing?

☐ planked boat ☐ Boat with engine ☐ Boat without engine

1.10. Which fish species do you sell? ☐ Chambo ☐ Micheni ☐ Matemba ☐ Usipa ☐ Mlamba ☐ Utaka

☐ Others (*Please specify*) _____

1.11. In what form do you sell the fish?

☐ Fresh ☐ Dried ☐ Smoked ☐ Parboiled ☐ Deep-fried ☐ Others

1.12. Which processing methods do you use?

☐ Sun-drying ☐ Smoking ☐ Parboiling ☐ Deep-frying ☐Solar-drying ☐ Others (*Please specify*) _____

1.13. What type of boats do you make?

☐ Planked canoes ☐ Wooden boats for artisanal fishers ☐ Wooden boats for pair trawlers

☐ Others (*Please specify*) _____

1.14. How long have you been involved in fish value chain?

☐ Less than a year ☐ 1-3 years ☐ 4-6 years ☐ 6-10 years

☐ Above 10 years

Section 2: Knowledge of climate change and its impacts

2.1. How much knowledge do you have about climate change?

☐ Good knowledge ☐ Some knowledge ☐ Little knowledge ☐ No knowledge

2.2. How much awareness do you have about how climate change can impact nature and society?

☐ Good awareness ☐ Some awareness ☐ Little awareness

☐ No awareness

2.3. When did you first notice there have been significant changes in climate/weather patterns? (Indicate the decade, e.g. 1980s) _____

2.4. How many drought/flood incidences have you witnessed in your lifetime?

i. Drought incidences: ☐ Never witnessed ☐ 1 to 5 ☐ More than 5

ii. Flood incidences: ☐ Never witnessed ☐ 1 to 5 ☐ More than 5

2.5. In which decade, would you say there has been frequent adverse weather events or climate/weather patterns in this area?

☐ 1980s ☐ 1990s ☐ 2000s ☐ Other (*Please specify*) _____

2.6. Can you recall some specific events in the last 5 years that have impacted your fishing activities?

☐ Heavy Mwera winds during seasons that are supposed to be calm

☐ Heavy rainfall

☐ Other events (*Please specify*) _____

2.7. Over the past five years, when did you experience these extreme weather events? _____

2.8. What type of extreme weather events have been common in this area in the last five years? (Multiple responses are allowed).

☐ Increased drought incidences ☐ Increased flood incidences ☐ Extreme temperatures ☐ Late rains ☐ Dry spells ☐ Early rains ☐ Persistent winds

2.9. How often did you experience these extreme weather events?

☐ Once ☐ Less than 3 times ☐ 3 to 5 times ☐ More than 5

2.10. What have been the consequences of these extreme weather events to your livelihoods? (*Multiple responses are allowed*)

☐ Crop damage ☐ Livestock loss ☐ Loss of life ☐ Loss of biodiversity ☐ Scarcity of water ☐ Low yields ☐ Low fish catches ☐ Damage to fishing vessels ☐ Damage to fishing gears ☐ Others (*Please specify*) _____

_____

2.11. What are the observed changes in the rainfall patterns in the last 10 to 20 years?

☐ No changes ☐ Early onset ☐ Late onset ☐ Erratic rainfall ☐ Poor distribution of rainfall

2.12. What are the observed changes in the rainfall intensity in the last 10-20 years?

☐ No change ☐ Decreasing ☐ Increasing

2.13. Do you have access to the weather forecasting data/information from the meteorological? department? ☐ Yes ☐ No

2.14. What is the source of this weather forecasting information? (*Multiple responses are allowed*)

☐ Radio station; ☐ Newspaper; ☐ Extension workers; ☐ Friends in the village; ☐ Household (Family) members; ☐Church; ☐ Meteorological Station; ☐ Other (*Please specify*) _____

2.15. Do men and women have the same opportunities in accessing weather information (*If the response is 2 or 3, please provide reasons*)?

☐ We have the same opportunities regarding access to weather information

☐ Men have more opportunities in accessing weather information than women

☐ Women have more opportunities in accessing weather information than men

Please specify the reasons here

_____

_____

_____

_____

2.16. Do you know any traditional methods/indicators of predicting weather?

☐ Yes ☐ No If YES to 2.16 above, name these indicators/methods used to predict weather patterns

Weather Hazzard	**Sign**
Mwera winds	
Zambwe	
Mpoto/Mvuma	
General Bad weather	
Stormy rains	

2.17. Mention the impacts of climate change that you have been observing in terms of:

i. Fish catches: are you catching the same amounts of fish as previous years

☐ We are catching the same amounts and same fish species as before

☐ We are catching the same amounts but different fish species as before

☐ We are catching less and same fish species as before

☐ We are catching less but different fish species as before

☐ We are catching more and same fish species as before

☐We are catching more but different fish species as before

ii. Fishing grounds: Do you catch fish in the same fishing grounds that you were catching fish in the previous years?

☐ We are catching fish in the same fishing grounds

☐ We are going further offshore to catch fish

☐ We are now catching fish closer to the shores than before

☐ Other (*Please specify*)

iii. Fishing gears used: Are you using the same fishing gears to catch the same amount of fish as in the previous years?

☐ We are using the same fishing gears to catch fish

☐ We have upgraded

☐ Other (*Please specify*)

iv. Are you still catching same quantities in the months that had more fish and in the months that had less fish, or the trend has changed and in which months?

☐ The quantities have remained the same in the following months _____
☐ The quantities have reduced in the following months _____
☐ The quantities have increased in the following months _____
☐ Please explain the change

_____
_____

2.18. Apart from fishing activities, has climate change affected you in other ways?

_____
_____
_____
_____
_____
_____

Section 3: Coping and adaptation mechanisms

3.1. Has your income from fishing activities changed over the past years:

☐ It has remained the same ☐ It has decreased ☐ It has increased

Please state the reasons

_____
_____
_____
_____
_____

3.2. Do you have alternative sources of income? ☐ Yes ☐ No

If the answer is yes: mention them (*Please tick more than one box if applicable*)

i. ☐ Casual employment in fisheries activities (this refers that you are involved for just a few days or less and not on permanent basis)
ii. ☐ Casual employment in other activities
iii. Farming
☐ Rainfed ☐ Irrigation
iv. ☐ Sale of food crops
v. ☐ Sale of cash crops
vi. ☐ Sale of fruits and vegetables
vii. ☐ Sale of livestock
viii. ☐ Sale of livestock products
ix. ☐ Off-farm activities
x. ☐ Remittances from family members

3.3. What means are you using to adapt to the impacts of climate change when doing fisheries related activities?

☐ Using climate resilient fish processing methods such as solar drying
☐ Using boats with engines to fish offshore
☐ Other (*Please specify*)_____

3.4. Have you received any fisheries extension services recently?

☐ Yes ☐ No

If yes, what topics were discussed?

☐ General fisheries extension

☐ Access to weather information

☐ Climate change adaptation and mitigation

☐ Other (*Please specify*) _____

3.5. Are there any interventions from government or NGOs that are dealing with climate change?

☐ Yes ☐ No

If yes, what are the interventions?

☐ Ecosystem management

☐ Weather information access

☐ Early warning systems

☐ Other (*Please specify*) _____

3.6. What are the problems being faced in your day-to-day fishing activities? *Please mention them*

_____

_____

_____

_____

_____

_____

DEDICATION

I dedicate this work to God Almighty for the wisdom, kindness, mercy and guidance throughout this journey.

To my dearest husband Alinane Thomas Munthali, you are one of a kind. I appreciate all your love and support throughout my journey and for stepping up as a parent.

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