ADAPTATION STRATEGIES OF SMALL SCALE FISHERS TO CLIMATE VARIABILITY AND CHANGE: A CASE STUDY OF LAKE VICTORIA IN MWANZA CITY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN RURAL DEVELOPMENT OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

The study on Adaptation Strategies of the Small Scale fishers to Climate Change was carried out in Mwanza City. Specifically the study aimed at (i) assessing fishers' awareness about climate change indicators affecting fisheries, (ii) analyzing micro-level climate change impacts facing fishers on their fishing activities and, (iii) analyzing fishers' adaptation to climate variability in the lake. Six villages commonly known as Beach Management Units (BMUs) were selected purposively and a total of 120 fishers were randomly selected and interviewed. Data were collected through administration of a structured questionnaire, Focus Group Discussion (FGDs), key informant interviews and direct observation. The Statistical Package for Social Sciences (SPSS) Computer Programne was used to analyse quantitative data where as content analysis was used for qualitative data. The results revealed that the ability of the fishers to adapt to the changing weather was affected by a series of factors; among others include poor fishing gears and equipments, lack of capital, low government support in the fishery sector, poor road infrastructures and lack of credit facilities to fishers. The study also found out that fishers have been changing the process and practices to moderate the effects of climate change to the fish catch; among others are the strategies of increasing capacity and efforts of fishing. The study revealed that over years the fish catch has always been declining while the climate change incidences such as excessive droughts, low rainfall, and high temperatures have been increasing. It was therefore reasonable to conclude that the present climate variability and change has a serious negative impact to fishers. It is very important for the government and other stakeholders to solve the problems associated with climate variability and change to fishers so that their ability to adapt to the adverse weather is improved.

DECLARATION

I, Mathayo Francis Maselle, hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my original work, and has not been submitted or concurrently being submitted for a higher degree award in any other University.

31/10/2012

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The above declaration is confirmed

31/10/2012

Dr. Nazael Madalla — Date

(Supervisor)

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DEDICATION

This work is dedicated to my beloved parents Benjamin Maselle (R.I.P) and Neema Maalim who laid down the foundation of my education and uncountable sacrifices for up bringing me. May the Almighty God rest the Soul of my father in Eternal Peace.

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LIST OF ABBREVIATIONS AND ACRONYMS

BMU	Beach Management Units
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
FMSP	Fisheries Management Science Programme
GDP	Gross Domestic Product
GHG	Green House Gases
IFMP	Implementation of Fisheries Management Plan Project
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LVEMP	Lake Victoria Environmental Management Project
LVFO	Lake Victoria Fisheries Organization
LVFRP	Lake Victoria Fisheries Research Project
MDG	Millennium Development Goals
MNRT	Ministry of Natural Resources and Tourism
NAPA	National Adaptation Programme of Action
NBS	National Bureau of Statistics
NEMC	National Environmental Management Council of Tanzania
NGO	Non Governmental Organisation
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
TAFIRI	Tanzania Fisheries Research Institute
TMA	Tanzania Meteorological Agency

TSH	Tanzanian Shilling
UK	United Kingdom
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USD	United States Dollar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate change is more than a warming trend. Increasing temperatures result in changes in many aspects of weather, such as wind. According to Intergovernmental Panel on Climate Change (IPCC), climate change is a human induced phenomenon as a result of various human activities on the earth surface for their survival (IPCC, 2007). The amount and type of rainfall and the types and frequency of severe weather events that may be expected to occur in an area. Climate change and the threat of related extreme conditions such as floods and droughts is a concern to all and has major implications for development, particularly for poor countries and communities have fewer resources to cope with the additional shocks and stresses a changing climate will bring. The changes in climate, the impacts on physical and biological systems, the vulnerability of ecological and human systems, and the harmful and beneficial consequences for human well-being and sustainable development will be conditioned by exposures to other stresses and the capacity to cope, recover and adapt, all of which will vary across space and time (IPCC, 2007). Indeed it threatens to undo many years of development efforts and frustrate poverty reduction programs in developing countries and overall global development targets (Stern, 2006).

Around the world, the climate is changing. Average global temperatures are rising – the 20th century was the warmest the world has seen 1980s and 1990s were the warmest decades on record. The IPCC's Third Assessment Report (2001) concluded that global warming has accelerated in recent decades and that there is new and stronger evidence that most of the warming over the past 50 years is attributable to the increase in greenhouse gas emissions associated with human activities.

In Africa and particularly Eastern Africa, global warming has had significant impacts on the once beautiful and glamorous mountains in the region. It has induced the gradual melting of ice caps on these mountains. For example snow caps on mountains Kilimanjaro, Kenya and the Ruwenzori have receded. About 83 and 40% of ice caps have been lost on mountain Kilimanjaro in Tanzania and Ruwenzori in Uganda, respectively (Lukwiya, 2009). Similarly, worth noting is that even major lakes and rivers in the region are already affected by impacts of climate change particularly raising temperatures and flooding. For example river Mubuku in Kasese, Uganda and Makalia falls in Nakuru National park Kenya are already drying due to raising temperatures and prolonged droughts (NAPA, 2007).

The anticipated temperature change and variation in rainfall patterns and amounts in East African region will have significant impacts on fisheries, agriculture, environment and natural resources, health and tourism among other social economic factors. This will therefore, directly affect the livelihood and economic development of countries in the region; for they are largely dependent on agriculture and natural resources as the main source of national revenues and community livelihoods. Furthermore, the impacts of climate change will undo the efforts of poverty reductions and delay achievement of the Millennium Development Goals (MDGs) in many of these countries by escalating hunger and human suffering.

1.2 Climate Change Impacts on Fisheries Sector in the Lake Victoria Region

Lake Victoria shared between Uganda, Kenya and Tanzania is the largest lake in Africa and important for Tanzania for its productive fishery, abundant water resources, hydropower production, biodiversity and numerous other uses. The lake is relatively shallow and thus sensitive to climate changes and can dry out quite easily (UN, 1999). The

river inflow is quite limited and the surface area is very large compared to its volume. Throughout its 400 000 year long history, Lake Victoria has dried out completely three times. Samples retrieved from the bottom indicate that the droughts were related to previous ice ages, and ice ages are known to cause a reduction of global precipitation. 17 000 years ago, Lake Victoria did not exist (Reader, 2001). The lake began to fill up again 14 700 years ago and the endemic species in Lake Victoria has therefore developed during a comparatively short period of time. Hepworth *et al*, (2008) reported that the benefits from Lake Victoria are questionable in the long term, given that the impact of climate change on commercial fishing on the lake is uncertain. Hence, any reductions in water level and the impacts of extreme climate events resulting from climate change may have significant negative effects on the lake. Higher temperatures may also have an impact on fisheries productivity and the ecology and species composition in the lake ecosystem, either directly or indirectly (Hepworth *et al*., 2008).

However, it is important to note that other factors influencing productivity of fish on lake cannot be ruled out entirely. These include pollution of lake water, which results in an increase in nutrients and reduction in oxygen in lake water, changes in the ecology of the fishery due to the introduction of non-native fish species and over fishing including fishing of young fish.

1.3 Problem Statement and Justification

The small scale fisheries produce about 90% of the total fish catch in the country; only 10% is derived from industrial fishing. Most of the fish caught is consumed locally while Nile perch and sardines are for export (TAFIRI, 2008). Fisheries sector contributes about 30% of the total protein intake to the Tanzanian population. It is a source of employment, livelihood to the people, recreation, and tourism. However, lake fisheries already experience high levels of climatic variability, which cause fluctuations in primary

production and fish yield as evidenced by a trend of declining rainfall and surface water availability, and other factors that affect productivity such as changing wind regimes (FAO, 2007). Adapting to such adverse weather poses another challenge to the small scale fishers whose adaptive capacity is low.

There has been a number of studies that investigated the vulnerability and adaptive capacity of the fisheries sector and dependent communities to climate change (Allison *et al.*, 2009). Nevertheless, until recently there has been little directed analysis at the local scale of how climate variability and change is affecting the lives and livelihoods of the small-scale fishers, who make up more than 90% of the worlds' fishers and fish traders (Badjeck *et al.,* 2009).

In the Lake Victoria zone in Mwanza City, fishers practice some adaptation strategies to cope with the changing climate and variability. Some of these strategies are either site or community specific and it is likely that they are not well known or even not adapted outside these areas. Their effectiveness is also not well known by researchers and policy makers. Furthermore, there has been very little intervention to create awareness and build the fishers' adaptive capacity to cope with the effects of climate change.

This study therefore aims at assisting in merging the indigenous knowledge and scientific knowledge so as to help the small-scale fishers to better adapt to the challenges climate change is posing on fisheries. Results from this study provide a good framework for decisions aimed at empowering the fishers who rely on fishing activities to adapt practices appropriate for mitigating climate change impacts. Although the study focuses on Mwanza city areas, it is held that the results generated from this study are relevant to many areas of

the country as well as other countries with similar climate and socio-economic structure in the Lake Victoria zone

1.4 Objectives of the Study

1.4.1 General objective

The general objective of this study was to investigate the adaptation strategies of the small scale fisheries following the effects of climate variability and change.

1.4.2 Specific objectives

The specific objectives of this study were as follows

i) To assess fishers' awareness about climate change indicators affecting fisheries;

ii) To analyze micro-level climate change impacts facing fishers on their fishing activities; and

iii) To analyze fishers' adaptation to climate variability in the lake.

1.5 Research Questions

This study was guided by the following research questions:

i) What do fishers consider to be indicators of climate variability?

iii) What are the felt impacts by small scale fisheries?

iv) How do small scale fishers respond to the impacts of climate variability?

1.6 Organization of the Thesis

This thesis is organized in five chapters. After this chapter one, Chapter two has presented an explosive review of literature, followed by study methodology in chapter Three. Results and discussion are presented in chapter four, while conclusions and recommendations are presented in chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of Fishery Sector

The fisheries sector is one of the main economic sectors in different countries (Salagrama, 2006). It has become a major source of livelihoods, creating a large income and Contributing to the poverty elimination. The fisheries sector has become a leader in enhancing countries trade relations with various markets and regions in the world (Salagrama, 2006). According to Konstapel and Noort (1995) as cited by Bokea and Ikiara, 2000), the Food and Agriculture Organisation of the United Nations (FAO) has estimated that the livelihood of 200 million people, 95% of them living in developing countries, directly or indirectly depends on fisheries. Salagrama (2006) reported that fish provides about 19% of the total animal protein consumed by African people. Overall, fish provide more than 2.9 billion people with at least 15% of their average per capital animal protein intake (FAO, 2010).

2.2 Lake Victoria Fisheries

Lake Victoria is one of the African Great Lakes, and the second largest lake in the world covering 68 800 km^2. The lake is shared by Kenya (6% by area), Uganda (43%) and Tanzania (51%). It has shoreline of 3450km, a water retention time of 140 years and a catchment area of 194 200km^2, which extends into Rwanda and Burundi (UN, 1999). The Lake Victoria basin is one of the most densely populated rural areas in the world. Its shores are dotted with cities and towns, including Kisumu, Kisii, and Homa Bay in Kenya; Kampala, Jinja, and Entebbe in Uganda; and Bukoba, Mwanza and Musoma in Tanzania (Figure 1). These cities and towns also are home to many factories that discharge their waste directly into the lake and its influent rivers. These urban areas also discharge raw

sewage into the river increasing its eutrophication that in turn is helping to sustain the invasive water hyacinth (NASA, 2007). The fishery is presently dominated by three commercial species: the introduced Nile perch and Nile tilapia (*Oreochromis niloticus*), and the endemic *dagaa*, a small pelagic cyprinid (*Rastrineobala argentea*) (Witte, 1992).

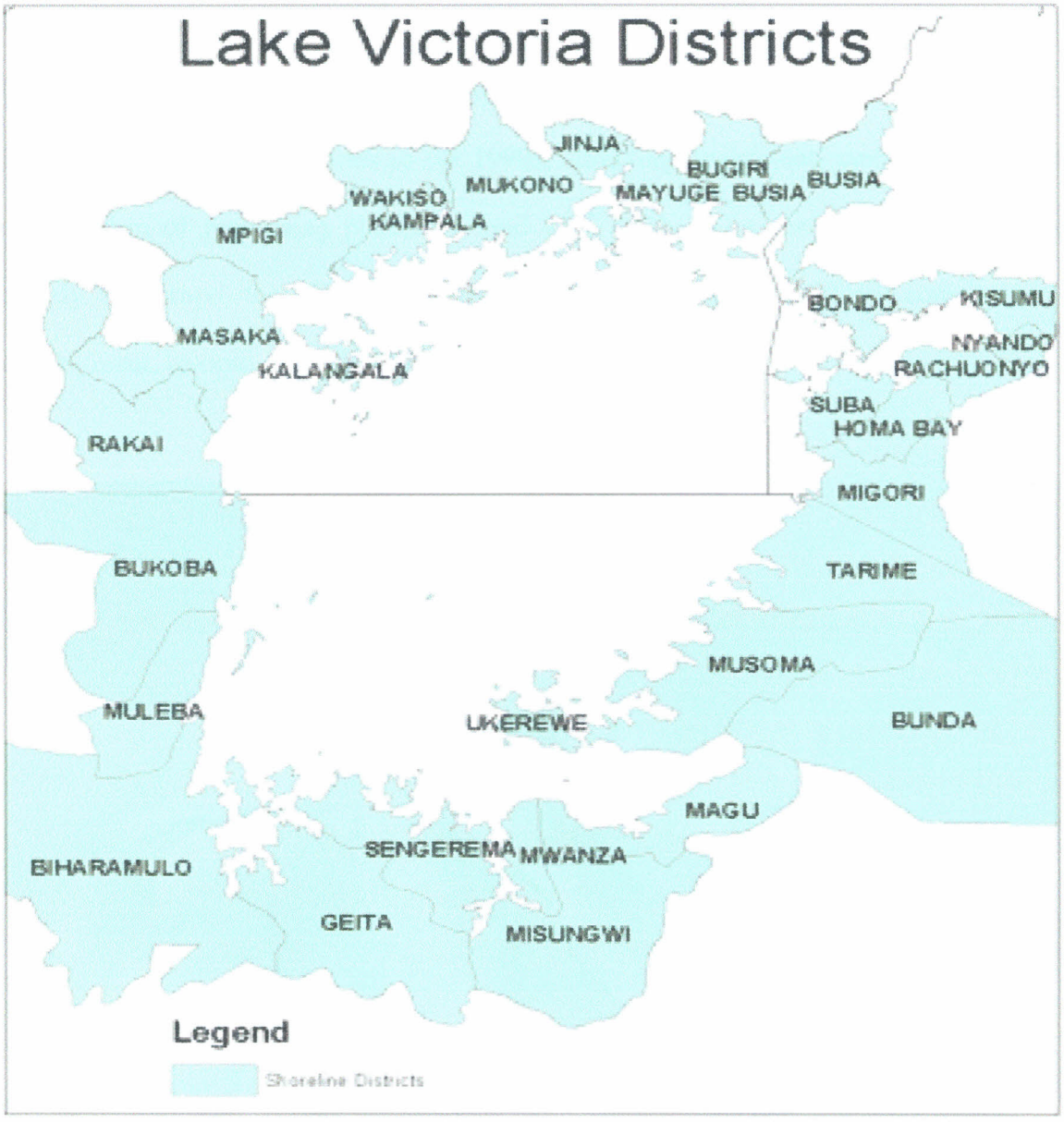

Figure 1: Lake Victoria Districts
Source: LVFO. 2010.

2.3 Main Commercial Fish Species

Lake Victoria fishery is mainly a commercial fishery, with artisanal fishers, working from motorized boats to non-motorized boats. There are three main commercial fish species in the lake.

2.3.1 Nile perch (sangara)

Nile Perch (Figure 2) was introduced to Lake Victoria in the 1950s and 1960s and led to the huge boom in the fisheries in the 1990s, attracting investment, more fishers and the construction of processing plants. Around 75% of the Nile perch landed is exported, mainly to Europe, the US and the Middle East, making a significant contribution to employment, income, GDP and foreign exchange.

Plate 1: Nile Perch (Sangara)
Source: Field Survey 2011

2.3.2 Sardine (Dagaa)

Dagaa (also known as mukene and omena) is a small sardine-like fish, most of which is dried and sold either for human consumption or for animal feed (Figure 3). Dagaa serves the local and domestic markets, but much is exported within the region, particularly the Democratic Republic of Congo, and even to Southern Africa. It is an important fish for the poor, as it is cheap and highly nutritious.

Plate 2: Dagaa
Source: Field Survey 2011

2.3.3 Nile Tilapia (Sato)

Nile Tilapia was also introduced to the lake in the 1950s and 1960s and mainly serves the domestic and regional markets, contributing to food security as well as income and employment.

Plate 3: Nile Tilapia
Source: Field Survey 2011

2.4 Contribution of Lake Victoria Fisheries to Tanzanian Economy

According to Onyango (2007), fisheries in Tanzania have continued to be a major contributor to the economy. The contribution of Lake Victoria fisheries to the economy is based on the fish production which has continued to grow especially since mid 1980s. However, in late 1990s and early 2000 the increase has been at a decreasing rate. Despite this, Lake Victoria's fish production remains the highest contributor to the overall fish production in the country (Onyango, 2005). The lake is known for its abundance of fish species (about 250 species), which are exploited by local small-scale fishermen (Bwathondi, 1990). Mgaya (2005) reports that the lake contributes about 60% of the total fish production estimated to be over 250 000 metric tons annually in Tanzania.

2.5 Climate Variability and Change

Climate is the prevailing or average weather conditions of a place as determined by the temperature and metrological change over a period of time (IPCC, 2007). There are various factors of climate and the most important are rainfall and temperature (NAPA,

2007). Climate change refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Climate change may be due to natural changes or to persistent anthropogenic changes in the composition of the atmosphere or inland use (IPCC, 2001 and 2007). Climate variability refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Nino and La Nina events (IPCC, 2001 and 2007).

Ishaya and Abaje (2008) asserted that, climate change is an environmental, social and economic challenge on a global scale. Climate change can be exacerbated by human induced actions such as: the widespread use of land, the broad scale deforestation, the major technological and socio-economic shifts (Millennium Ecosystem Assessment, 2005). Abaje and Giwa (2007) revealed that the most devastating adverse impacts of climate change in Nigeria and other subtropical countries includes frequent drought, increased environmental damage, increased infestation of crop by pests and diseases, depletion of household assets, increased rural urban migration and increased biodiversity loss. Others include depletion of wildlife and other natural resource base, changes in the vegetation type, decline in forest resources, increased health risks and the spread of infectious diseases and changing livelihood systems.

2.6 Climate Change Causes and Key Actors

2.6.1 The main causes of climate change

The major cause of climate change is the production of green house gases from human activities including agricultural production, industrialization, burning of fossil and bio fuels, and deforestation among others (Stern, 2006). These gases react with the thin layer

(ozone) which protects the earth from direct heat from the sun. When this layer is depleted, sun rays hit directly on the earth resulting in temperature raises which influence climate on the earth. These changes manifest as global warming, prolonged droughts, and unreliable rainfall.

2.6.2 The key Actors

The developed countries particularly United States of America and European Union among others are the largest producers of these emissions and hence the largest contributors to climate change (Praveen, 2005). However, developing countries such as China and India with rapid economic growth are beginning to have an increasing contribution to climate change. African countries contribute very little emissions, but the effects of climate change are still very high. Climate change has socio-economic, political and demographic (through migration) impacts, which many fear will lead to increased societal tensions and violent conflict (Burke *et al.*, 2009). Higher surface temperatures in Africa will negatively affect agricultural productivity and economic performance, thereby raising the incidence of civil unrest and conflicts (SeeBrown and Crawford, 2008). The loss of household assets - in particular, livestock - due to droughts, has affected livelihoods and led to widespread famine (Meier *et al.*,2007).

2.7 Climate change in Tanzania

Recent studies have suggested that, alongside other East African countries, climate change has badly affected the country (Shemsanga *et al.,* 2010). Studies show that in Tanzania mean annual temperatures and average daily temperatures will rise by between 2 to 4oC by 2075 as a direct consequence of climate change (URT, 2003). Putting Tanzania into a wider African context however, it is projected to warm up less than many countries

notably north-western and southern Africa (URT, 2007). Interestingly, the interior parts of the country are projected to face higher temperature increases than coastal areas whilst cold and dry seasons will warm more than warm and wet seasons (Mwandosya, *et al.*, 1998). Apart from temperature data, change in rainfall patterns is likely to be more torturous and with immediate severe effects. In Tanzania, rainfall models indicate that rainfall will become less predictable and their intensity more volatile (IPCC, 2001). Tanzania expects to have a decrease in rainfall by between 0 to 20% in the inner parts of the land. Northeast, southeast and the Lake Victoria basin however, expects to have a total increase in rainfall by between 20 to 50% (Mwandosya, *et al.*, 1998). Such major changes in rainfall patterns will inevitably have severe consequences to the society, some of which (repeated droughts and floods) are already happening (Mwandosya *et al.,* 1998).

2.8 Potential Impacts of climate change to fisheries

Climate change can impact fisheries through multiple pathways. Changes in water temperature, precipitation and oceanographic variables, such as wind velocity, wave action and sea level rise, can bring about significant ecological and biological changes to marine and freshwater ecosystems and their resident fish populations (Badjeck *et al.*, 2009), directly impacting peoples whose livelihoods depend on those ecosystems. Extreme weather events may also disrupt fishing operations and land-based infrastructure, while fluctuations of fishery production and other natural resources can have an impact on livelihoods strategies and outcomes of fishing communities (FAO, 2007).

The impacts of the above-mentioned changes on fisheries-dependent and aquaculture dependent communities will be as varied as the changes themselves. In general, the strength of these impacts will depend on the vulnerability of each community. The

vulnerability depends on the sensitivity of the community and its exposure to the impacts, as well as its adaptiv

Aquatic-resource-dependent communities may face increased vulnerability in terms of less e capacity (Fig. 5).

stable livelihoods, decreases in the availability and/or quality of fish for food, and risks to their own health if, for example, fishing under harsh weather conditions or farther from their home base. Overall, the impacts will result in changes, both positive and negative, in production and marketing costs, changes in the prices for fishery products, and increased risks of damage to or loss of infrastructure, tools and housing.

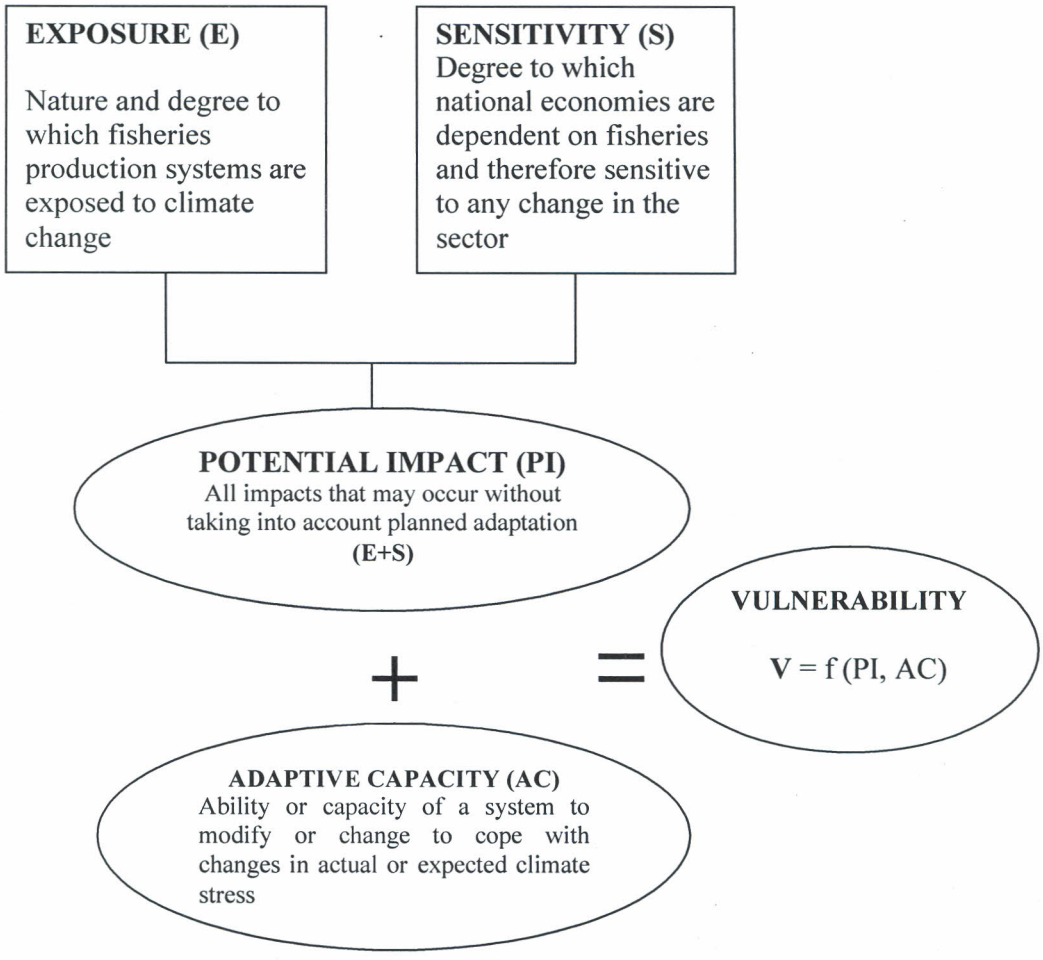

Figure 2: Summary of factors determining vulnerability of fisheries dependent communities

Source: FAO.2007. Building adaptive capacity to climate change

Fisheries located in the high latitudes and those reliant on systems particularly susceptible to climate change, such as upwelling and coral reef systems, appear to have the highest potential exposure to impacts (FAO, 2008). In general, for the inland fisheries, temperature changes are likely to impact cold-water species negatively, warm-water species positively, and cool-water species positively in their northern ranges and negatively in their southern ranges. Also, there will likely be a general shift of cool- and warm-water species northward in northern hemisphere rivers. The abundance and species

diversity of riverine fishes are predicted to be particularly sensitive to climatic disturbances, since lower dry season water levels may reduce the number of individuals able to spawn successfully. The timing of flood events is a critical physiological trigger that induces fish to migrate and spawn at the onset of the flood which enables their eggs and larvae to be transported to nursery areas on flood plains (FAO, 2008). In addition, fisheries communities located in delta or on coral atolls and ice-dominated coasts will be particularly vulnerable to sea level rise and the associated risks of flooding, saline intrusion and coastal erosion (FAO, 2008). Of particular concern will be those regions with low adaptive capacity to change, such as the countries of sub-Saharan Africa (SSA). Riparian communities without proper extreme-weather adaptation programmes, in terms of infrastructure design, early warning systems and knowledge of appropriate behaviour, will also be at high risk.

However, recognizing the high growth potential for aquaculture in Africa and Latin America, as well as in other regions, there is the need to address climate change implications in these continents, more specifically in relation to future aquaculture developments. New opportunities and positive impacts (e.g. from changes in species and new markets) will also be part of future changes. At the moment, these opportunities are not well understood, but they will depend on adaptive capacity.

2.9 Adaptation Responses

Adaptation is defined as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages to or benefit from opportunities associated with climate change (IPCC, 2001). Adaptive capacity

describes the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. It requires amongst many other things, the flexibility to experiment and adopt novel solutions. In ecosystems, adaptive capacity is related to genetic diversity, biological diversity, and heterogeneity within landscapes (Carpenter and Gunderson, 2001). In social systems, adaptive capacity can be a conscious or inadvertent characteristic, enhanced by the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving, without compromising the ability to cope and adapt to future change (Jansen and Osnas, 2005)). Adaptive capacity greatly influences the vulnerability of communities and regions to climate change effects and hazards (Adger and Vicent, 2005).

2.10 Tanzania's Vulnerability to Climate Change

Climate change is likely to have a wide range of interrelated impacts for the environment, economy and well being of Tanzania which are likely to be significant for the future development trajectory of Tanzania (Hepworth, 2010). Thus economic valuations of climate change impacts can be useful in heightening the political priority afforded to adaptation planning (Hepworth, 2010). The economic costs of climate change for Tanzania have been estimated at between 1.5 to 2% of GDP by 2030, a total of $270 million each year (UNEP, 2009). The country's climatic projections show that annual temperatures may rise by 2.2°C by 2100, with somewhat higher increases (2.6°C) over June, July, and August, and lower values (1.9°C) for December, January, and February, with greater warming for the cooler months (June–August), compared to the warmer months (December–February). Annual precipitation over the whole country is projected to increase by 10% by 2100, although seasonal declines of 6% are projected for June, July, and August, and increases of 16.7% for December, January, February (Agrawal *et al.*,

2003). Given variations in altitude, topography, vegetation, and coastal proximity, changes in rainfall patterns and temperature are expected to vary considerably from one part of the country to another (URT, 2003).

Since most of the economic activities depend heavily on climate change-sensitive sectors, such as agriculture, livestock, fisheries, forestry, water, and unmanaged ecosystems, the possible impacts of climate change on fisheries sectors is also expected. While many tropical fishes have evolved to survive in very warm waters, rising water temperatures as a result of climate change might affect those fish that have critical heat thresholds and cannot survive temperatures that exceed this threshold. An increase in mean temperature may also affect the dissolved oxygen concentrations, limiting oxygen supply (Fick *et al.*, 2005). The resulting reduction in productivity is demonstrated at the stratified northern end of Lake Tanganyika, which supports a less productive fishery than the well-mixed southern arm and the main basins (Bezabih *et al.*, 2010). A comparative study of historical and current levels of primary production in the north end of Lake Tanganyika also indicates that current levels are much lower as a result of strengthened stratification (Bezabih *et al.*, 2010). Limited dissolved oxygen has also led to changes in the limnology of Lake Victoria and has negatively affected its fishery (Bezabih *et al.,* 2010).

2.11 The State of Climate Variability and Change in Lake Victoria Basin

Lake Victoria was reported to have warmed by 0.3°C from 1960-61 to 1990-91 with an apparent increase in thermal stability (Hecky *et al.*, 1994). The data obtained from two recent surveys conducted by the Lake Victoria Fisheries Research Project (LVFRP) which ran from 1999-2001 and the implementation of a Fisheries Management Plan Project (IFMP) which began in 2005 indicated that considerable warming appears to have taken

place with both surface and bottom waters having increased by about 1.0°C and 1.3°C respectively over a period of 81 years (Table 2) This gives an average rate of change of around 0.012°C per year in surface water and 0.017°C per year in deep waters, which is comparable to the rate of 0.01°C per year obtained earlier. The rate of warming also appeared to have accelerated over the last decade, the survey indicated that in the 73 years from 1927 to 2000 the surface and bottom temperatures increased by 0.36°C and 0.59°C respectively, while they increased by 0.63°C and 0.75°C in the eight years from 2000 to 2008 (Table 4). The annual rate of warming from 2000-2008 was thus an order of magnitude greater than it had been in the 1927-2000 period. Generally, over the long term, global warming may bring adverse changes in rainfall patterns and river flows which are likely to have a major impact on the Lake.

Table 1: Changes in temperature in Lake Victoria from 1927 to 2000, and from 2000 to 2008

	1927-2000		2000-2008	
	Surface	**>50m**	**Surface**	**>50m**
Difference (°C)	0.36	0.59	0.63	0.75
Rate of Change (°C/yr)	0.005	0.008	0.079	0.094
Decrease in Density (g/m^3)	0.112	0.146	0.156	0.200

Source: Graham (1927) & LVFRP and IFMP Surveys (2001 & 2005)

2.12 Climate Change on Lake Victoria Water Levels

Lake Victoria is highly sensitive to climate variability, as illustrated by the fluctuations in the water level of Lake Victoria in the past (Goulden, 2006). Other lakes in the region show similar patterns of historical variability to Lake Victoria. Fluctuations in rainfall in the catchments of the rivers that drain into the lake have a large effect on Lake Victoria's water level. Fluctuations in lake water level due to climate variability have had an impact

on infrastructure around the lake such as water supplies for towns, irrigation and possibly also on fish stocks in the lake (Herpworth and Goulden, 2008). Some people have suggested a link between dropping of lake levels and the decline in fish catches from Lake Victoria (Goulden, 2008).

Average lake levels in the future may be reduced by higher evaporation from the lake's surface due to higher temperatures unless increases in rainfall outweigh this effect (Herpworth and Goulden, 2008). One study using a hydrological water balance model showed that lake levels might fall on average in the early part of this century and then be higher on average than current levels in the second half of this century (Tate *et al.*, 2004). However, Tate *et al.,* (2004) reports that, the modelling of average lake levels in the future is highly sensitive to the particular climate scenarios used and hence very uncertain. In addition to changes in average temperatures and rainfall conditions, climate variability is expected to continue or increase in the future. If the projected increase in annual rainfall is experienced as more extreme events, then we can expect more frequent and/or more extreme flooding events and sharp rises in lake level in the future.

2.13 Climate Change in African Lakes

Evidence of climate induced changes to the thermal structure of African lakes is beginning to emerge. In Lake Kivu, for example, Lorke *et al.,* (2004) indicated that, the temperature of the upper layer of the water column apparently increased by 0.5°C over thirty years, while in Lake Malawi the temperature increased by 0.7°C over 60 years (Villmer *et al.*, 2005). The most noticeable impact was reported from Lake Tanganyika where the temperature at 100-150m depth increased at a rate of 0.01°C per annum (O'Reilly et al, 2003). The rate of increase in deeper water was much lower and this led to a trebling of

the density gradients, thus increasing thermal, stability and hindering mixing. As a result, productivity has declined because the circulation of nutrients trapped in the deeper waters has been reduced, mostly by increased thermal stability and partly by a weakening of the trade winds that drove the upwelling of deep waters (Verburg *et al.,* 2003 and O'Reilly *et al*., 2003).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

This chapter describes the study area and methodology employed in the study. Section 3.2 describes the study area. Research design and procedures for sampling the population are outlined in section 3.3 and 3.4 respectively, while section 3.5 describes the data collection process, and the techniques used for data analysis are presented in section 3.6. Section 3.7 presents the challenges in the field.

3.1 Description of the Study Area

The study was conducted in Mwanza City, one of the areas located on the southern part of the Lake Victoria in Northwest Tanzania. The city is constituted with two Districts (Nyamagana and Ilemela). It covers an area of 1325 Km^2 of which 900 Km^2 (68%) is covered by water and the remaining land area is 425 Km^2 (32%) (Mwanza City Profile, 2005). Regional wise, the city takes around 3.77% of the whole area of Mwanza Region (URT, 2003).

Annual population growth is estimated to be 3.2%, which is higher than the national population increase rate of 2.8% (Mwanza City Profile, 2005). Currently, Mwanza city is expected to have a population size of 476,646 people (i.e. Nyamagana 210 735 and Ilemela 265 911 people) (URT, 2003). The rural to urban immigration being at around 8% (URT, 2002). It is also estimated to have 87 132 households where by each household is estimated to have an average number of 7 people which surpasses the national average of 5 people (Mwanza City Profile, 2005). The population density shows that there are 1462 people in every sq. km of dry land, being the second after Dar es Salaam (URT, 2002).

3.1.1 Climate

Mwanza City lies at an altitude of 1,140 metres above the sea level. Mean temperature ranges between 25.70C and 30.20C in hot season and 15.40C and 18.60C in the cooler months (Mwanza City Profile, 2005). The City experiences between 700 and 1000mm of bimodal rainfall per year between the months of October and December and between February and May.

3.2 Research Design

A cross-sectional research design was used in the study. According to Bernard (1994) and Babbie (1999), the design allows data to be collected at a single point in time. This design was considered to be favoured due to time and resource limitations for data collection (Casley and Kumar, 1988).

3.3 Sampling Procedures

3.3.1 The sample

The sampling unit was the individual fisher. It was preferred as the ultimate sampling unit since it is the most appropriate unit of measure when assessing the adaptation strategies practiced by fishers against the effects of climate variability and change. The study intended to sample respondents with an age from 30 years old and above. This minimum age limit was considered as an important factor in this study assuming that the respondents at this age are likely to have noticed some climatic variations during the past twenty years.

3.3.2 Sample size

Following Boyd *et al.* (1981), a sample (n) was chosed such that it was at least equal to or greater than 5% of population size identified in the study area. However due to financial and

time constraints, it was not possible to sample the 5% of 13,000 of the existing population of fishers. Therefore, a total number of 120 respondents were sampled from six villages. The sample size was found to be convenient for statistical analysis, well beyond the recommended bare minimum sample size of 30 to allow meaningful statistical analysis (Bailey, 1994). A summary of the distribution of respondents involved in the study is given in Table 2.

3.3.3 Sampling technique

Sampling strategies involved simple random sampling and purposive sampling procedures to obtain villages and respondents of the study. Using purposive sampling technique, 6 out of 17 villages were selected guided by the City Fisheries Officer, where by 2 villages were selected from Nyamagana District and 4 villages were selected from Ilemela District. Simple random technique was used to obtain 120 respondents which was the study population size, 20 respondents from each village were interviewed. To cover the information on fishing activities, a modified definition of a fisherperson was adopted. A fisherperson was defined as somebody who catches fish as an occupation for a living. It, however included those who migrated from other areas but currently claim to be members of the village.

3.4 Data Collection

3.4.1 Primary data

The main methods used in collecting primary data were questionnaire survey and key informants' interview. The structured questionnaire was formulated of both closed and open-ended questions.

Respondents were tracked using the leaders of the Beach Management Units (BMU). To enhance the chance of meeting the fishermen in their landing beaches, early morning time was found to be appropriate time. In this study eight key informants including six BMU's chairmen, one City fisheries officer and one officer from Tanzania Meteorological Agency (TMA) were interviewed. The interview was guided by a well structured checklist to gather their views toward the impact of climate variability and change to small scale fishers. The interview questions focused on a more comprehensive range of issues including socioeconomic status (fishing vessels size, number of vessels, literacy, marital status, income, sex and age), climate change trends, climate variability impact on the livelihood and the society, and adaptation strategies.

To ensure validity and reliability, the first draft of questionnaire was pre-tested to ten fishermen and key informants. Necessary changes were made on the basis of pre-testing results before administering the final questionnaire. This included restructuring of, and omission of some questions. The pre-tested fishermen were not included in the main survey.

3.4.2 Secondary data

Relevant and available data, published literature, policy documents and other relevant sources were gathered from relevant institutions and organizations such as Sokoine National Agricultural Library (SNAL), Tanzania Fisheries Research Institute (TAFIRI), Ministry of Natural Resources and Tourism, Fisheries Division and National Bureau of Statistics-Mwanza Region and Tanzania Meteorological Agency (TMA). Other information was obtained from electronic sources in the internet.

Population data by the National Bureau of Statistics (NBS) have been used to look at population growth in Tanzania in general and Mwanza city in particular. These gave a picture of the socio-economic characteristics of the population in the study area.

3.5 Data Processing and Analysis

The collected information was analyzed using statistical package for social sciences for Windows (SPSS 11.5) computer programme. Basically, descriptive statistical method was used in this study based on the objectives where frequencies, percentages and means were computed.

Primary data was analyzed using both qualitative and quantitative methods. Objectives (i) To assess fishers' awareness about climate change indicators affecting fisheries, (ii) to analyze micro-level climate change impacts facing fishers on their fishing activities, and (iii) To analyze fishers' adaptation to climate variability in the lake are exploratory in nature and were analysed using descriptive statistics procedure of SPSS to yield frequencies and percentages.

3.6 Conceptual Framework of the Study

Climate change often ascribes changes in fish catch to changes in seasonal weather patterns. The nature or extent of climate variation depends on how people are aware about climate change and variability (Fig. 3). The impacts felt by fishers can be described as negative if climate variations result into low rainfall, occurrence of floods, irregular rain seasons, and persisted aridity or droughts indicated by undesirable outcomes like low fish catch. The impact in turn determines what response option or adaptation fishers undertake

in an attempt to counteract the effects emanating from climate change and variability. Better adaptations will mitigate the problem of climate change.

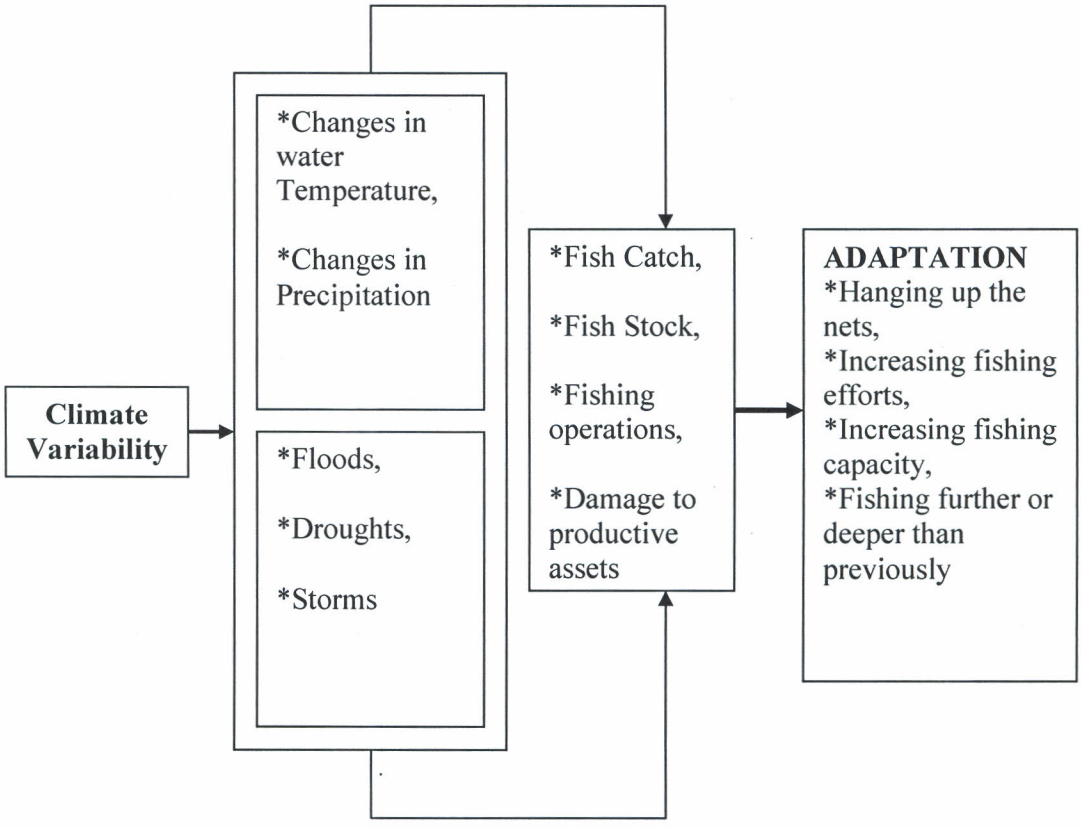

Figure 3: Conceptual framework on adaptation strategies of small scale fisheries to Climate Change

3.7 Limitation to the Study

The research faced two major challenges that impeded greatly the onset of interviews and data collection procedures.

3.7.1 The national general election campaigns

Firstly, data were collected during the National election campaigns in October 2010, most of the respondents were also involved in campaigns and hence it was a bit difficult to interview some of the respondents. However, very early morning time was appropriate before onset of campaign activities.

3.7.2 The annual fish catch and income

Most of primary information for the study was collected through interview. Error resulted from respondents as one of the limiting factors relying on the respondents to recall exactly how much they earn annually and how is the annual fish catch from fishing activities at different seasons.

Therefore, in spite of the above limitations, it is expected that the data collected were reliable and adequate to address the objectives of the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Beach Management Units (BMUs) and Fishing Activities

The study was done in six villages commonly known as Beach Management Units (BMUs). These included Kigoto, Mihama, Bwiru, Butuja, Mkuyuni and Sweya villages. These BMUs were chosen purposefully basing on the presence of large number of respondents in a given village (Table 2). BMUs are villages by themselves, most of which are small business centres with shops and markets. The population in such villages is high with an average of 300 families per site. BMUs have been formed to complement the fisheries conservation and management activities of the Village Environment Committee. The BMUs were formed under the Lake Victoria Environmental Management Project funded by the World Bank (FMSP, 2008). Under the fisheries Act No. 22 of 2003, the BMUs roles and responsibilities are identified. Currently there are more than 500 BMUs newly reformed around Lake Victoria on the Tanzanian side with the overall objective of participating in fisheries resource management (Fisheries Division, 2006). BMUs are rather recent invention of mangers of fisheries as a vehicle for mobilizing and involving fishers in management of fisheries. They were identified as strong linkages between the Government, the fishers groups and other stakeholders. Pomery and Rivera-Guieb (2005) defined stake holders in the community-based co-management as individuals, groups or organizations of people who are interested, involved or affected (positively or negatively) by the use and management of fisheries resources.

Table 2: Distribution of all respondents (n=120) involved in the study

District	Villages	Number of respondents
	Sweya	20
Nyamagana	Shede	20
	Kigoto	20
	Mihama	20
Ilemela	Bwiru	20
	Butuja	20
Total		**120**

Source: Own survey data

Fishing activities in the selected sites is a major source of employment to a substantial riparian lake population. The fishery has created employment to fishermen, fish processors and fish traders. Observation made on the sites indicated that, on average there are about four fishermen per boat. At the beach, there are many women and few men who purchase the fish from fishermen and they either sell the fish to the local consumers or sell them to the fish processors.

4.2 Respondents Social Economic Characteristics

This chapter presents and discusses the main findings of the study. The characteristics of a respondent interviewed have important social and economic implications to the adaptation strategies practiced by fishermen against the effects of climate variability and change to fish catch. Therefore this section describes the characteristics of sampled respondents, focusing mainly on respondent's sex, age, marital status, education level, family size, income and general information on factors affecting the ability to adapt to the fluctuating weather.

4.2.1 Age of respondents

Age of the respondent is an important factor that could be used to not only tell the variation in climate conditions over the years but also tap into indigenous knowledge practices that are a pointer to climate change adaptation (KRC, 2011).

Results in Table 3 show that fishing activities in the selected villages was dominated by fishermen with the age between 41 and 50 years which accounted for about 43%, where as the age between 31 and 40 accounted for 36.7% and the age between 51 and 60 accounted about 15%. The last group was those with the age above 60 years old who accounted for about 5% only. The age of an individual has influence on the ability of that individual to adapt to the changing weather. Results also show that, old people constitutes a very small proportion of fishers, this is due to the fact that old people are more likely that are incapable of venturing further due to old age. KRC (2011) also reported that farmers aged below 30 years only observed physical changes and probably read about the climate variability and changes but could not tell what happened in the greater part of the last century. From the age sets of the respondents it can be seen the views of senior citizens were sought who could narrate the changes in climate for over 3 decades by physical observation (KRC, 2011).

Table 3: Age of Respondent

Variable	Category	Frequency	Percentage
Age	31-40	44	36.7
	41-50	52	43.3
	51-60	18	15.0
	>60	6	5
	Total	**120**	**100**

Source: Own survey data

4.2.2 Sex of the fisher

Among the respondents interviewed, male fishers were (100%) (Table 4). Adeoti et al., (2010) reported that 80% of the fishers in Lagos are male while females are 19.7% which indicates that fishers are mostly male. The reason for this disproportionate distribution of gender among fishers is because fishing is a tedious task which involves spending long hours on the off-shore in pursuit of catching fish, hence males are more involved (Adeoti et al., 2010). Even though fishing is often considered as a risky and dangerous occupation, men engaged in fishing have high levels of job satisfaction (Allison and Horemans, 2005), making the identity of being a fisher desirable.

Table 4: Sex of the Fisher

Variable	Category	Frequency	Percentage
Sex	Male	120	100
	Female	0	0
	Total	**120**	**100**

Source: Own survey data

4.2.3 Marital status of the respondents

The study considered marriage of respondents as one of the key factors that may influence individual's ability to adapt to effects of climate variability and change. In this study marriage was considered to include formal unions, and was categorized as Single, Married, Separated and widowed. The distribution of fishermen according to the type of marriage is presented in Table 5.

The results demonstrated the status of marriage among the fishermen to be as follows: 55.8% of all the fishermen interviewed were married, 20% separated, 13.3% living single and another 10.8 % were widowed. Married respondents are more likely to have poorer

adaptive capacity to climate change than the single one. Adeoti et al, (2010) reported that marital status is of great importance because of its potential source of labour that can be made available for fishing.

Table 5: Marital Status of the Respondents

Variable	Category	Frequency	Percentage
Marital Status	Single	16	13.3
	Married	67	55.8
	Separated	24	20
	Widowed	13	10.8
	Total	**120**	**100**

Source: Own survey data

4.2.4 Education level of the respondents

This study considered education as one of the factors which influences respondent's ability to adapt to the changing climate. The fishers without formal education are likely to be more vulnerable to climate variability than fishers with formal education when other factors remain constant (Adeoti *et al.,* 2010).

The study revealed a moderate rate of literacy in the study area. About 56% of the respondents had at least primary education, 22.5% of fishermen had attained secondary education and 21.7% of respondents had adult education (Table 6). From these results, it can be pointed out that the overall literacy status of the fishermen in the study area was sufficient (100%). According to Prapaland (2009), education has a key role to play in promoting understanding and helping individuals, society and governments to make informed choices. For climatic change adaptation strategies to be promoted sustainably, education is a key, and assessing the levels of education for any affected community, helps

to design the mechanisms for effective delivery of the required climatic related information for sustainable development. The higher the education level the greater the chances for interpreting the environmental policies and the higher chances for innovation for better climate change adaptation and response mechanisms. Education could take both the formal and informal and enables exposure of communities to external knowledge for better learning and making informed choices. High literacy level implies that the respondents would be able to understand innovation easily and other information from extension workers, which help in improving their catch (Adeoti *et al*, 2010).

Table 6: Education Level of Respondents

Variable	Category	Frequency	Percentage
Education level	Adult education	26	21.7
	Primary education	67	55.8
	Secondary education	27	22.5
	Total	**120**	**100**

Source: Own survey data

4.2.5 Fisher's family size

On average, the size of families of the fishers interviewed was found to be 5 persons per fisher (Table 7). Characteristics across the study area showed a slight variation in size of the families; overall number of people per fisher's family ranged from 1 to 9 persons with most families having 4-6 persons per fisherman. About 61% of the total number of fishermen interviewed had families ranging from 4 to 6 persons, followed by 21.7% of fishers who have families with above 6 persons per fisherman, and the last one were those having 0-3 persons (17.5%). Sanga (2006) reports that in general, the overall number of people per fishers' family ranged from 1 to 9 persons with most families having 4-6 persons per fisher. However, Adeoti et al., (2010) reported that in Lagos, family size of

between 4 and 12 are represented by about 73% of the respondents. Large family size suggests labour availability for fishing activities.

Table 7: Fishers Family size

Variable	Category	Frequency	Percentage
Family Size	1-3	21	17.5
	4-6	73	60.8
	>6	26	21.7
	Total	**120**	**100**

Source: Own survey data

4.2.6 Source of income of the respondents

This study considered the source of income as one of the factors which influences respondent's ability to adapt to the effects of climate variability and change. Individuals with other sources of income apart from fishing alone are more likely to have high adaptive capacity. This is because what they get from non-fishing activities enable them to support fishing activities during unfavourable weather conditions. Results in Table 8 shows that 60% of the total number of respondents interviewed in the study area had only one source of income, i.e fishing, where as 40% had other sources of income (i.e. farming, small business, carpentry and stone quarrying). This indicates that fishing activities was the major source of income for the majority of people in the study area. Geheb *et al.,* (2007) reported that, in every community, fishing attracted almost all of a fisherman's labour and generated all of his income. Even when the fishery was closed, there was no evidence to suggest that men sought to diversify into alternative economic sectors. Fishing will always yield at least a little cash every day (Geheb *et al.,* 2007).

Table 8: Source of Income of the Respondent

Variable	Category	Frequency	Percentage
Source of Income	Fishing	72	60
	Fishing/others sources	48	40
	Total	**120**	**100**

Source: Own survey data

4.3 Other Livelihood Sources

The other livelihood sources (Non-fishing activities) ranged from small business to stone quarrying (Table 9). About 51.7% of the respondents are engaged in small business in village centres along the lake beaches, about 30.8% of respondents practice farming, where as about 12.5% of respondents engage themselves in Carpentry works and lastly about 5% of them engage in stone-quarrying. Goulden (2008) found that many of the actions that households take to adapt to the impacts of climate variability depend on diversifying their livelihoods-taking up different activities to earn income and obtain food – whilst others depend on social bonds. This ability to diversify livelihood can be limited by insufficient human capital, insufficient natural capital and insufficient social capital (Goulden, 2008). Other activities are economically important but not directly linked to the fishers livelihoods. However, where a member of the fishers' family is engaged in any of these activities, it means additional income source for the family (FMSP, 2008).

Table 9: Other economic activities

Activity	Frequency	Percentage
Small business	62	51.7
Farming	37	30.8
Carpentry	15	12.5
Stone quarrying	6	5
Total	**120**	**100**

Source: Own survey data

4.4 Situational Characteristics of Fishers

4.4.1 Boat ownership

Results in Table 10 show that 65.8% of the respondents owned the fishing vessels and only 34.2% of them did operate fishing activities by renting boats. The study revealed that fishers who owned boats were better off and more adaptive to the changing weather than those who rent boats. Boat ownership, boat renting and possession of fishing gears are important determinants of total fishing income (catch). Therefore, boat ownership and rental costs are used as proxies of fishing capacity (Sesabo and Tol, 2005). The fishermen who operate fishing activities by renting they pay in cash or rent under special agreement (i.e payment is done in terms of produce). Here an agreement involves an arrangement of distribution of the catch in a week. The dominant distribution practice that is common to the majority of fishers in Lake Victoria was that which involved giving catch of five days to the owner of the boat and two days to the fishers. MNRT/JICA (2002) reports that, the lease condition s are harsh for the fishers as rental charges may vary between Tshs 5000 to 20 000, or fishers may be required to pay 15% of sales and to sell all their catch to the engine owner.

Table 10: Respondent's fishing vessels (Boat)

Variable	Categories	Frequency	Percentage
Ownership	Rented	41	34.2
	owned	79	65.8
	Total	**120**	**100**
Type of vessels	Paddled	109	90.8
	Fuel powered	11	9.2
	Total	**120**	**100**
Number of vessels	One	80	66.7
	Two	35	29.2
	Three	5	4.2
	Total	**120**	**100**
Size of vessels	Less than one tone	43	35.8
	One tone	58	48.3
	Two tones	19	15.8
	Total	**120**	**100**

Source: Own observation

Most fishing in the study area was carried out in shallow water around the shores that were easily accessible from fishing villages and landing sites using mostly non-motorized boats and different types of gear (hand line, gill net surrounding net, purse seine, long line and fish traps). Fishers with motorized boats were able to travel further than fishers with non-motorized boats. Distance reached by fishers determines the abundance and size of fish harvested. Young and small in size fish are found near the beaches. This situation implies that young and small fish are highly fished as the majority of fishers cannot travel further the interior where older fish are obtained. Of the total number of boats in the study area, 9.2% were motorized, where as 90.8% were non-motorized boats (Table 10). Motorization improves fishing efficiency and enables fishers to access more distant, less exploited areas, but should be selected carefully to ensure the additional costs are recovered through increased catch and fish quality, hence the need to properly consider the gear type, and

size and type of vessel (FMSP, 2008). The most easily reached sites are facing serious fishing pressure and overexploitation with no time given for natural recovery. Adeoti (2010) reported that fishers using motorized boats had higher net income than those using non-motorized boats. It was then concluded that this is due to the fact that improved technology reduces the drudgery associated with fishing and enhances quantity of catch. Fishers with motorized boats can therefore better adapt to the changing weather.

4.4.2 Access to credits

The study revealed that none of the fishers had access to credit as shown in Table 11. The majority of small scale fishers use own capital for investment in fishing activities. This has an obvious implication on the scale of operation and the fisher's income. In other words, lack of access to credits means inadequate capital for investing in fishing activities and hence low adaptive capacity. Fishers who have no access to credits for investment in fishing are more likely to be vulnerable to the changing weather. Rural financial services accessible by fishers were few and inadequate. It was reported that these credit facilities had not been very favourable to fishers as the interest rates are high, and the application process is very cumbersome. FMSP (2008) reports that, full-time fishers rarely sought credit from financial institutions. Those who sought credits involved in trading of fish and fish related products rather than fishing. Financial Institutions are reluctant to offer loans for purchasing boats and engines for fear that borrowers may sell them and claim they are stolen (FMSP, 2008). Bank managed credit facilities feel that fishing is risky, and are hence wary of issuing credit to small scale fishers. They set stringent conditions that discourage small fishers from applying (FMSP, 2008). Microfinance is a tool that can reduce the vulnerability of the poor and the possibility of linking this tool to climate change adaptation is of considerable importance (Hammill et al., 2008). In this study,

99.2% of the respondents believed that lack of access to credits is an hindrance to adaptation to climate variability where as 0.8% of them still could operate fishing activities without credits (Table 12).

Table 11: Distribution of respondents by access to credits

Access to credits	Frequency	Percentage
No	120	100
Yes	0	0
Total	120	100

Source: Own survey data

Table 12: Distribution of respondents by need of credits

Need of credits	Frequency	Percentage
Yes	119	99.2
No	1	0.8
Total	**120**	**100**

Source: Own survey data

4.4.3 Estimated annual income of the respondents

The study did take the annual income of respondents as the key factor that may influence the respondent's fishing capacity following the effects of climate shocks in the lake. Individuals with high annual income are likely to have high ability to adapt to the effects of climate variability and change. Results in Figure 8 show that the overall estimated annual income of the fishermen ranged from 1 to 12 million Tsh with most fishermen ranging from 1-4 million Tsh. About 55% of the total number of fishermen had an annual income ranging from 0.5-4 million Tshs, followed by 27.5% of fishermen who had annual income ranging from 5-9 million Tsh, and the last ones were those with an estimated annual income of more than 9 Million Tshs, and these comprised about 17.5% of the total

number of fishermen. A study carried out in five countries (Bangladesh, India, Malaysia, Tanzania and Senegal) found out that, in the case of Tanzania the average annual household income of the fishers was found to be significantly higher than that of households in neighbouring villages (FAO, 2001).

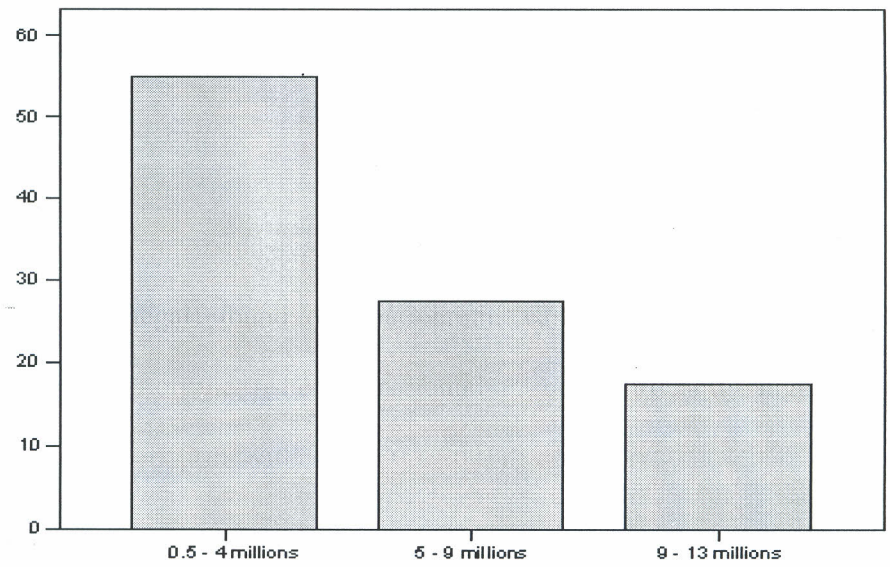

Figure 4: Estimated annual income of fishers

4.6 Respondent's Awareness About Climate Variability and Change

The study considered this aspect of awareness as the principal factor that may influence fishermen's ability and preparedness to adapt to the effects of climate change. The fisherman who is aware of the trends of climate variability and change is likely to be more protected than the one who does not. The study revealed that, respondents were served with information about climate change through different modes of information. Results in Table 13 shows that, about 58% of fishers interviewed got information about climate change through personal observation, while 25.8% of respondents were informed through mass media and 15.8% were informed by the Non Government Organizations (NGOs). From these results, it can be pointed out that the overall awareness status of the fishermen

in the study area was sufficient (99.9%), where as high rate of own observation indicated that the effects of climate change was very obvious to fishermen. Similarly, a study in Uganda reported that 78% of respondents got informed about climate change through personal observation, where as 13% were informed through radios and news papers (KRC, 2011). Radios and news papers show that mass media are critical sources of information on climate change thus indicating relevance of education in terms of ability to read and write.

Table 13: Fishers' information about Climate change

Mode of information	Frequency	Percentage
Mass Media	31	25.8
NGOs	19	15.8
Own observation	70	58.3
Total	120	100

Source: Own survey data

4.7 Movement of Fishers

This study considered movement of people from one village to another as one of the strategies of adapting to the changing weather. The fishers tend to move to areas where catch is high. Fiona (2010) reported that, migration forms an essential livelihood strategy for many fisherfolk in the developing world, largely responding to fluctuating fish availability and prices. On Lake Victoria, most migration is characterized by movement between landing sites, particularly for responding to localized changes in fish productivity and using social networks to identify better fishing grounds and areas of higher fish prices (Fiona, 2010). Vulnerability due to lower catches and reduced income is mitigated through movement which in turn leads to risky sexual behaviour and increased fishing pressure. Results in Table 14 show that 65% of the respondents in the study had immigrated from

other villages, where as 35% of them were natives. This indicates that the majority of the fishers tend to move from one place to another as a strategy of adapting to the adverse weather. Therefore, moving to the less affected area means trying to maintain the catch.

Table 14: Distribution of fishers by natives and migrants

Native	Frequency	Percent
Yes	42	35
No	78	65
Total	**120**	**100**

Source: Own survey data

4.8 Fishers' Adaptation to Climate Variability

This study considered adaptation practices carried out by fishers as the principal solution of reducing the negative impact of climate variability and change. From the study findings given in Table 15, among the interviewed fishers the findings show that 100% of all the respondents were at least fishing further and deeper than previously as a strategy of adapting to climate variability, 97.5% were at least increasing fishing efforts, 60% were at least increasing fishing capacity, 34.2% were at least hanging up the nets, where as 45% of respondents responded to the effects of climate change by switching off from fishing to business, 8.3% were at least switching off from fishing to salaried employment, 6.7% were at least switching off from fishing to agriculture and 1.7% of the respondents declared that they had no any adaptation strategy. This implies that about 98% of the respondents had knowledge of climate change adaptation strategies. The study revealed that, the strategies of fishing further and deeper than previously and that of increasing fishing efforts (i.e. spending much time in fishing) are the practices mostly used by fishers to reduce the effects of climate variability and change. When describing current and past

adaptation strategies in the Rwenzori region, KRC (2011) reported that the majority of the respondents (85%) had knowledge of climate change adaptation strategies.

Table 15: Adaptation strategies practiced by fishers

Strategy	Response	Frequency	Percent
Hanging up Nets	Yes	41	34.2
	No	79	65.8
Increasing Fishing Efforts	Yes	117	97.5
	No	3	2.5
Increasing Fishing Capacity	Yes	72	60
	No	48	40
Fishing further and deeper	Yes	120	100
	No	0	0
Switching to Agriculture	Yes	8	6.7
	No	112	93.3
Switching to Business	Yes	54	45
	No	66	55
To salaried employment	Yes	10	8.3
	No	110	91.7

Source: Own survey data

4.9 Causes of Climate Change

There were many causes of climate change mentioned by the respondents with the most commonly reported ones being pollution which accounted for about 36%, bad farming practices accounted for about 31%, cutting of trees accounted for about 25% and lastly poor fishing methods accounted for about 8% (Table 16). UN Report on Climate Change (2007) reports that agriculture has been shown to produce significant effects on climate change, primarily through the production and release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide, but also by altering the earth's land cover, which can change its ability to absorb or reflect heat and light, thus contributing to radiative forcing. Land use change such as deforestation and desertification, together with use of fossil fuels, are the major anthropogenic sources of carbon dioxide; agriculture itself is the major

contributor to increasing methane and nitrous oxide concentrations in Earth's atmosphere (UN, 2007). Fishing with explosives, use of poisons and inadequate practices like fishing gears that damage resources and /or the environment, beach seining and bottom trawling can eventually cause changes in climate (FAO, 2010). Expanding coastal populations are exerting an ever-increasing pressure on coastal waters, thus negatively affecting water quality. Reports indicate that coastal waters fronting such cities and towns as Dar es Salaam, Tanga, Zanzibar and Mtwara are grossly polluted (Mohamed 2000). Pollutants include both domestic and industrial waste. Therefore it is logical that climate changes mentioned by respondents have a contribution to the climate change.

Table 16: Respondents' action to change the climate

Causal factors	Frequencies	Percentage
Pollution	43	35.8
Farming Practice	37	30.8
Cutting trees	30	25
Poor fishing methods	10	8.4
Total	**120**	**100**

Source: Own survey data

4.10 Local perception of Indicators of the Climate Change

Small scale fishers in Mwanza City had developed perceived indicators of the changes in climate through indigenous knowledge. There are many indicators which were mentioned by respondents which include, prolonged drought, high temperature, drying of vegetation, drop of Lake water level and change of rainfall seasons (Table 17). About 100% of the respondents in this study said they had observed some indicators associated with climate change. Other indicators include low fish catch, too much rainfall and strong winds. As asserted by Ishaya and Abaje (2008), indigenous people in Nigeria perceived that the

environment, climate in particular, has been changing over the years due to diverse human activities. In South Africa for instance, a study by Gbetibouo (2009) revealed that higher proportion of farmers claimed temperature is increasing and rainfall is decreasing, and noted change in the frequency of droughts and floods.

Table 17: Respondents' Perceived Climate Change Related indicators

Indicators	Frequency	Percentage
Low fish catch	26	21.7
Low water levels	25	20.8
Prolonged drought	21	17.5
Drying of vegetation	16	13.3
High temperatures	14	11.7
Change of rainfall season	10	8.3
Too much rains	5	4.2
Strong winds	3	2.5
Total	120	100

Source: Own survey data

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Fishers have a good knowledge of climate change, its causes and effects. The study therefore concludes that, the overall awareness status of the fishers in the study area is sufficient; whereas high rate of personal observation indicated that the effects of climate variability and change are obvious and have high impact on fishers' livelihood.

During the past ten years fish catch has always been declining while the climate change incidences such as excessive drought, floods and other famines have been increasing. It is therefore reasonable to conclude that the present climate variability and change has a serious negative impact on fish catch and to fishing dependent community.

Some fishers in the study area have devised climate change adaptation strategies. Some of these strategies are effective in the short term. Indigenous response and adaptive mechanisms on their own will certainly not be enough to respond to climate change. The study revealed that for the past ten years, fishers have been changing the process, practices and structure to moderate potential damages or to benefit from opportunities associated with climate change. The respondents in the study area have been using strategies of fishing further and deeper than previously by using mostly non-motorized boats which are not strong enough to operate against adverse effects of climate change. Therefore it is logical to conclude that the small scale fishers have very weak ability to adapt to the changing climate, the situation which in turn affects the fish catch.

5.2 Recommendations

Based on the conclusion drawn from the findings the following recommendations are made:

(i) There is a need to address and support other livelihood activities to fishers. Among the alternative livelihood earning activities, farming is basic to all fisher communities. Others include stone quarrying, carpentry and cooked food supply which area also more important for women. Aquaculture is a potential alternative activity, but it needs to be developed and requires training and resources.

(ii) Integrating climate change adaptation considerations into policy processes and decision-making across a fishery sector is critical in managing the impacts of climate change. Efforts to achieve this objective, might be undertaken under the direction of the Government, and/or independently through actions supported by the private sectors, NGOs, and international financial institutions. There is a need to develop, disseminate and implement the knowledge, tools and technologies required to effectively enable the small scale fishers to better adapt to the adverse weather. Information campaigns, coupled with appropriate coordination and leadership could help in addressing some of the problems. Public education on issues of climate change, population, environment policy/natural resources, leadership role for overall civic competence, action and advocacy. Awareness could include, infusing awareness in schools, involving village environmental committee, involving the media by empowering journalists in understanding climate change impacts and adaptation strategies, educating decision makers on climate change matters (special seminar/training sessions, conducting special climate change seminars for members of parliament). In addition, involving

churches, mosques and village councils to create awareness of climate change, integrating climate change news in popular culture such as music and films and making use of politicians to incorporate climate change issues in their campaign slogans could be important way forward. Radio, TV, magazines, newspapers and leaflets could be important conduits of climate change in disseminating climate change issues.

(iii) The small scale fishers wish to improve their catch through acquisition of better fishing gear and motorized vessels. This requires capital, which they do not have. Credit facilities to the small scale fishers are not easily available because creditors categorize fishing as high-risk investment. This dilemma could be overcome through formation of viable fishers' cooperative organizations through which credit and donor and/or government support could be channeled. In general, this study suggests that there are several factors that could be affected by public instruments. These factors are related to input quality, specifically the acquisition of improved gears and vessels and provision of market access. Accordingly, government policies should be geared towards increasing and improving access of small-scale fishers to capital. This would allow them to increase investment in modern fishing tools. This will not only help in reducing pressure on inshore fishing ground but also improving their efficiency. In line with this view, there is a need to promote investment in infrastructure so that fishers can gain access to markets with their products.

(iv) The study covered small scale fishers only on investigating their adaptation strategies following the effects of climate variability and change in Lake Victoria, Mwanza; it did not cover medium and large scale fisheries. It is therefore

suggested that future research should be conducted in other areas along the Lake Victoria regions and compare results. Furthermore, Reliable information on the fishers' income and expenditure is limited. As an information gap, this is an area that needs further study. The study will be important to enable planners to project the needs and support required to improve the livelihoods of the fishers.

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APPENDICES

Appendix 1: Questionnaire 1 Questionnaire on the Study of Adaptation Strategies of Small Scale Fisheries to Climate Variability in Mwanza City, Tanzania

SECTION A: Background information. Please answer the following questions sincerely.

Respondent's name.....

Name of Enumerator.....

Date of interview.....

Time started.....time finished.....

1. Village name.....
2. Ward.....
3. Division.....
4. District.....
5. Were you born in this village? 1. Yes 2. No
6. In case you were not born in this village, fill in the following table:

Migrated from (Village, district)	Year	Reasons

Codes (reasons for migration)

1=marriage; 2= Accompanied parents; 3=Fishing in high catch area; 4=employment transfer; 5=searching for wage work; 6=Others (specify)

7. Are you married?

1=Yes, still together; 2=Yes, separated; 3=No, single; 4=Widowed; 5=Others (specify).....

8. Please circle your age bracket: **1.** (35-40) **2.** (41-50) **3.** (51-60) **4.** (60+)

9. What is your education level?

1=Adult education; 2=Below std VII; 3=Std VII; 4=Below Form IV; 5=Form VI

10. Fishing vessels/canoes: . (specify size and numbers)

11. What type of fishing vessels? 1=Fuel powered 2=Paddled

12. What is your estimated annual income from fishing?

13. Household size: .persons

14. Are there fisheries extension services in your area? (1) Yes (2)No

15. If yes, do you get such services? (1) Yes (2)No

16. Are there any institutions dealing with credit services in the area? (1) Yes (2)No

17. If yes have you ever accessed loans for fishing activities? (1) Yes (2)No

18. If yes, what specifically did the loan assist you in your fishing activities?

Purchased :(1) Fish Nets(2) Vessels (3)others (please specify).....

SECTION B: Farmers' awareness about climate indicators affecting fishing.

19. Are you aware of the fact that currently the weather has been varying ?(1)Yes (2)No

20. If yes, what do you think are the indicators that the weather has been behaving abnormally?(i).....

(ii).....

(iii),..... (iv).....

21. What used to be the state of temperature before 1980s?(1) warm (2) cool (3) more extreme (4) Don't know
22. What has been happening in terms of the number of the hot days/months of the year in the past 20 years?

    (1) Have increased (2)have stayed the same (3) have decreased (4) don't know
23. Why do you think so? Please explain the reasons for your response in question 19.....
24. Have you witnessed any change in rainfall over the past 20 years? (1)Yes (2)No
25. If yes what has been happening in terms of the number of days/ months of *vuli* rains in the past 20 years? (1) Have increased (2)have stayed the same (3) have increased (4) don't know
26. If there are changes how long (days/months) have the *vuli* rains been lasting in a year in the past 20 years? (1) less than a month (2) 1 month (3) 2 months (4)3 months (5)more than 3 months
27. What has been happening in terms of the number of days/ months of *masika* rains in the past 20 years? (1) Have increased (2)have stayed the same (3) have increased (4) don't know
28. How long (days/months) have the *masika* rains been lasting in a year in the past 20 years?

    (1) less than a month (2) 1 month (3) 2 months (4) 3 months (5) more than 3 months
29. Have you ever experienced any droughts in the area for the past 15 years? (1)Yes (2)No
30. If yes, what has been the frequency of drought occurrence in recent years (now up to 15 years ago)? (1) Increased (2) Decreased (3) No change (4)Don't know

31. What can be the reasons for these climatic variations observed above? Please circle the right answer.

    (1) Human activities (2) Climate change (3) Punishment from God due to increase in evils(4) gods are angry because people have stopped offering sacrifice (5) others

32. Can you please list the events/activities corresponding to the answer you have provided in question 31?.....

SECTION C: Micro-level climate impacts facing fishers:

Please select the best answer from the alternative answers provided.

33. Who are the people seriously affected by climate change?

    1. The poor **2.** The rich **3.** None 4. All

34. The threat of climate variations is more on:

    1. Health

    2. Fish catch

    4. Fuel costs

    5. Productive assets and homes

    6. Risks of accidents in Lake

    7. Lake water levels

35. Have you ever faced any climatic related impact in your life time? 1. Yes 2. No

    If yes, what type of climatic shock? .....

36. If the answer to Q 35 is yes, did it affect the fish catch? 1. Yes 2. No

    If yes, how? .....

37. If the answer to Q 36 is yes, how did you cope or what did you do to cope with the situation?.....

38. How did the Government, GOs and NGOs respond to reduce the impact? .....

39. Which type of climatic shock is your main concern? .....

Kindly use the options below to answer the following questions according to your level of agreement or disagreement:

1–Strongly Agree, **2**–Somewhat Agree, **3**–I Don't Know **4**–Somewhat Disagree, **5**–Strongly Disagree

40. Climate change has lead to decline in fish catch .....

41. The costs of fish are increasing because of climate change.....

42. The Lake water level suffers from excessive droughts due climate change.....

43. Climate change has lead to influx of migrant fishers .....

44. Climate change incidences have lead to damage to productive assets and homes.....

45. Climate change has caused improvement of fishing system. .....

46. Variations in climate have destabilized fishing system. .....

47. Variations in climate have caused an increase in incidences of floods during the raining season.....

48. Incidences of droughts have increased due to climate fluctuations.....

49. Some fish varieties have no longer been available due to persistent droughts in the area.....

50. Climate variability has been causing frequent famines in the area due to decline in fish catch.....

Kindly supply with the correct responses in the following questions

51. Can you please tell which year had good (adequate) fish catch in the past 5 years? (1) 2006; (2) 2007; (3) 2008; (4) 2009; (5) 2010. Please tick the appropriate response. State the estimated annual catch.....

52. Which year had poor fish catch in the past 5 years? (1) 2006; (2) 2007; (3) 2008; (4) 2009; (5) 2010. (Please tick the appropriate response). State the respective annual catch .....

53. How do you characterize the weather of this area in terms of its temperature and precipitation?

    Is there any change? 1. Yes 2. No, If yes how? .....

SECTION D: Climate change and adaptation options

54. Does climate variability have any impact in your fishing activities? (Yes/No)

55. If yes, have you made any adjustments so as to reduce the impacts of climate variability? (Yes/No)

56. If yes below are strategies in adapting to fluctuations in climate. State whether you practice or not.

    A. Hanging up the nets (Yes/No)

    B. Increasing fishing efforts (Yes/No)

    C. Increasing fishing capacity (Yes/No)

    D. Fishing further or deeper than previously (Yes/No)

    E. Switching from fishing to agricultural activities (Yes/No)

    F. Switching from fishing to business (Yes/No)

    G. Switching from fishing to salaried employment (Yes/No)

    H. The use of dynamites and katuli (Yes/No)

I. Changing fishing seasons (Yes/No)

57. What other adjustments in your fishing activities have you made to the changing weather? (Please list) .....

58. What do you recommend to be done that will help people to better cope with problems caused by climate variability?.....

59. What are the perceived hindrances to adaptation of modern techniques of combating climate change?

1. Lack of improved fishing gears (Yes/No)

2. Lack of access to credits (Yes/No)

3. Lack of current knowledge on adaptation methods (Yes/No)

4. Lack of information on weather incidences (Yes/No)

5. Lack of money to acquired modern techniques (Yes/No)

6. There is no hindrance to adaptation (Yes/No)

7. Others (Yes/No) (Please mention) .....

Thank you for your cooperation!

Appendix 2: Checklist Questions for Key Informants

Mwanza City/Fisheries Sector Officials, Development Agents and TMA

1. Name……..……..Position/Profession……
2. Is there any noticeable form of climate change in Mwanza? 1. Yes 2. No

   If yes, can you explain?.....
3. If the answer to question 2 is yes, would you explain the extent of climate variability and change impact on fisheries?.....
4. Has there been any change in fish catch? 1. Yes 2. No

   If yes, what factors could be responsible?

   1……2……..3……4……..
5. What are the periods of low fish catch in Mwanza? ……..……..
6. What is the annual catch in tons for the past 5 years?

   2006……2007……..2008……...2009……2010……...
7. What is the annual income for the past 5 years?

   2006……2007……2008……2009……2010……
8. What are the parameters of rainfall and temperatures for the period of 10 years?

   ……
9. What is the impact of climate variability and change on fishery dependent communities in Mwanza? ……..
10. What are the local coping mechanisms used to reduce the impacts? ……...
11. What are the institution efforts to reduce future impacts? ……..……
12. What are the main challenges and how do you think they can be improved?……

Thank you for your cooperation!