SOCIO-ECOLOGICAL DRIVERS AND DYNAMICS OF *LIMNOTHRISSA MIODON* ON LAKE TANGANYIKA: A CASE OF MPULUNGU DISTRICT

BY

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A dissertation submitted to The University of Zambia in partial fulfillment of the requirements for the award of Degree of Master of Science in Environmental and Natural Resources Management.

THE UNIVERSITY OF ZAMBIA

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DECLARATION

I, **George Kambonge,** do declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree to this or, any other university. All citations and sources of information are acknowledged herein by way of references.

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APPROVAL

The dissertation prepared by George Kambonge is approved as fulfilling part of the requirement for the award of the Degree of Master of Science in Environmental and Natural Resources Management of The University of Zambia.

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Supervisor

ABSTRACT

The dissertation examined drivers that contribute to the decline of *Limnothrissa miodon* on Lake Tanganyika. Explicitly, the research study pursued; (i) factors that contribute to the reduction of *Limnothrissa miodon,* (ii) effects of not sustaining *Limnothrissa miodon* on fishers and marketeers and (iii) strategies that could be used to sustain *Limnothrissa miodon*. The case study research design targeted fishers, marketeers, and key discussants. Qualitative methods were used to capture the attitude, views, ideas and opinions of respondents on the reduction of *Limnothrissa miodon.* Snowball sampling, and expert purposive sampling techniques were used. One hundred and twenty-four (124) respondents were sampled through theoretical saturation in Kasasa, Kabatwe, Musende fishing villages and Ngwenye market. Questionnaires, Focus Group Discussions (FGDs), and interview schedules were used as data collection instruments. Thematic analysis was adopted to make codes, and give meanings. Ninety-two (92) respondents representing seventy four per cent (74%) attributed indiscriminate fishing to the reduction of *Limnothrissa miodon*. Twenty-seven (27) respondents representing twenty-two per cent (22%) attributed the increase in the population of fishermen, and marketers to the reduction of *Limnothrissa miodon*. On the other hand, five (5) respondents representing four per cent (4%) attributed climate change to the reduction of *Limnothrissa miodon*. This study, subsequently, recommends the introduction of fishing quotas, bag limits, fisher licensing, closed seasons, size limits, aquaculture practices, creation of freshwater reserves, and freshwater-protected areas. The study suggests further research on the prevalence of wrong fishing gear, and illegal fishing methods.

Key words: Socio-ecological, Drivers, Dynamics, *Limnothrissa miodon*, Lake Tanganyika.

DEDICATION

As a subject matter specialist, the researcher tried in the very best of his knowledge and capacity to bring to pass this unique dissertation. Lo and behold, he has run his race to set the pace in the subject covered. He has left the trail for his ancestors and/or descendants, and the future generation respectively. Therefore, this section as a personal matter is devoted to family members, spouse and children.

ACKNOWLEDGEMENT

This dissertation was intended to deliver competent and dependable evidence vis-à-vis the subject covered. Consequently, the preparation of this publication is indebted to those who generously took their time and effort to offer valuable comments and suggestions on how dissertations and/or theses must be written. On the other hand, Socio-ecological Drivers and Dynamics of *Limnothrissa miodon* is an academic dissertation that outlined the outcomes of the study that took place along the bank of Lake Tanganyika in Mpulungu District of Northern Province of Zambia. It is, therefore, supplemented by drivers of biomass reduction of *Limnothrissa miodon,* effects of not sustaining *Limnothrissa miodon* on fishers and marketeers and includes strategies that can be used to enhance the sustainability of Kapenta. Hence, the preparation of this dissertation benefited from noteworthy contributions from stakeholders through countless consultative processes at both the academic and individual levels.

Truthfully, I would like to express my profound gratitude to God the Father, God the Son and God the Holy Spirit for His Gracious opportunity to permit me to bring this dissertation to completion. Certainly, all glory, honour and praise go to God Almighty for the anointing biblical values that usher into what then looked difficult and later on impossible to the human eye. So, my honest appreciations exceptionally go to my family for their patience and tolerance during the time I have been studying and the subsequent completion of this research. May God bless you, for the love and inspiration you have been showing me. I would like to convey my authentic gratitude to ***Dr. Mweemba,*** my research supervisor for his close and altruistic contributions and guidance and for rephrasing the research topic to what it is. Appreciation is extended to ***Dr. Umar*** for the academic assistance rendered to me during the time I have been studying and for reviewing the three-paged research proposal in the inception. Appreciation also goes to ***Dr. Nyanga*** for giving me a reason to continue with my studies at the time I almost gave up. Great appreciation is extended to Mr Mbewe, Assistant Director – Aquaculture, Department of Fisheries for rendering a listening ear in the initial stage of this dissertation and for the maiden data received on the status of *Limnothrissa miodon* catches on both Lake Tanganyika and Lake Kariba. All texts of good will before, during and after this study are profoundly treasured.

Wholeheartedly, I would like to recognize the contribution of my friend, former roommate and classmate at Kasaka Fisheries Training Institute, Mr Sing'andu for all the information given to me, before, during and after data collection. He played an essential role in the data collected. Mr Sing'andu, I thank you for your time and effort in this noble cause. Furthermore, genuine appreciation goes to Mr Chifunda, a former fisheries staff who collaborated well in this activity. The study in Mpulungu District was a success due to his good public relations during data collection as he translated the ***Lungu language*** to the researcher during data collection. Special thanks extended to Dr Banda Vincent, District Fisheries and Livestock Coordinator of ***Mulobezi District*** for the time rendered to me in my studies and eventually the compilation of this dissertation. I would also like to honestly convey my appreciation to the senior members of staff in the ***Ministry of Fisheries and Livestock*** and ***NARDC*** staff that I met while at the ***National Aquaculture Research Development Centre***, Mwekera in Kitwe for providing technical and logistical support in the process of collecting data.

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ABBREVIATIONS AND ACRONYMS

BMU	-	Beach Management Units
CpUE	-	Catch per Unit Effort
CR	-	Catch and Release
CGLE	-	Coastal and Great Lake Ecosystems
DPSIR	-	Driver Pressure State Impact Response
DWFM	-	Distant Water Fisheries Management
DRC	-	Democratic Republic of Congo
DOF	-	Department of Fisheries
EFLC	-	Economic Framework of Local Communities
EMS	-	Environmental Management System
FAD	-	Fisheries and Aquaculture Department
FD	-	Framework Directives
FPM	-	Fisheries Production Management
FRC	-	Fisheries Resources Conservation
FRCM	-	Fisheries Resources Conservationists and Managers
FMcFA	-	Fisheries Management concerning Foreign Affairs
FWEP	-	Fisheries Water Environmental Protection
FVM	-	Fisheries Vessel Management
FPM	-	Fisheries Port Management
FGD	-	Focus Group Discussions
FPA	-	Freshwater Protected Areas
FFD	-	Freshwater Framework Directive
FFP	-	Future Freshwater Policy
FMR	-	Fisheries Management Research
FMS	-	Fisheries Management Systems
FEbFM	-	Fisheries and Ecosystem-based Fisheries Management
FE	-	Freshwater Environment
FM	-	Fisheries Management
FME	-	Fisheries Management Efficiency

GRZ	-	Government Republic of Zambia
GBF	-	Global Biodiversity Framework
GDP	-	Gross Domestic Product
GEF	-	Global Environmental Facility
GES	-	Good Environmental Status
IPCC	-	International Panel for Climate Change
ITQ	-	Individual Transferable Quotas
ICQS	-	Individual Catch Quota Systems
IUUf	-	Illegal, Unreported and Unregulated fishing
IMEA	-	International Millennium Ecosystem Assessment
KFTI	-	Kasaka Fisheries Training Institute
LF	-	Legislative Frameworks
LTDP	-	Lake Tanganyika Development Project
NARDC	-	National Aquaculture Research Development Centre
NOAA	-	National Oceanic and Atmospheric Administration
PMS	-	Participatory Management System
PDD	-	Philosophies and Developmental Directions
PPHCR	-	Precautionary Procedure and Harvest Control Rule
RFMO	-	Regional Fisheries Management Organizations
RbFS	-	Right-based Fishing System
RbFS	-	Right-based Fisheries System
RbFM	-	Right-based Fisheries Management
SMFA	-	Supervision and Management of Fisheries Administration
SES	-	Social-ecological System
SES	-	Socio-ecological System
SES	-	Socio-ecosystem
SEM	-	Socio-ecological Model
TAC	-	Total Allowable Catch
USD	-	United States Dollar
UN	-	United Nations
URT	-	United Republic of Tanzania

UNFAO	-	United Nations Food and Agriculture Organization
VCDC	-	Village Conservation and Development Committees
ZCFM	-	Zambia's Capture Fisheries Management
ZD	-	Zambian Directive

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Zambia is endowed with several natural resources that include water, forests, and wildlife (Sichilongo et al., 2012). Zambia's water abundance of twelve million hectares is in form of rivers, lakes, and eight million hectares of wetlands (Shula and Mukuka, 2015). Biological resources in these water bodies support the livelihoods of a vast majority of the rural population, and for commercial exploitation of resources at the national level (Ministry of Tourism, Environment, and Natural Resources, 2006). Benefits derived from biological resources contribute to the wealth of Zambia in some ways at household, community, and national level (Ministry of Tourism, Environment and Natural Resources, 2006). While agriculture is the most important source of livelihood, Zambia's hectares of water in rivers, lakes, and swamps provide the basis for extensive freshwater fisheries (FAO, 2006). On the other hand, everyone in Zambia irrespective of socio-economic status enjoys the consumption of fish (FAO, 2006). However, demand for domestic fish for consumption still surpasses production. The Government of the Republic of Zambia is fully aware of the direct benefits of fish as a source of food of high nutritional value, especially for vulnerable groups (FAO, 2006).

Certainly, fish forms about 55% of the total animal protein intake for the people of Zambia (Ministry of Fisheries and Livestock, 2018). Despite its considerable importance, the gap between supply, and demand is currently increasing (Ministry of Fisheries and Livestock, 2018). The present demand for fish is estimated at around 185, 687 metric tonnes annually though production is estimated at 106, 472 metric tonnes (Ministry of Fisheries and Livestock, 2018). There is an apparent shortfall of about 79, 215 metric tonnes while; human population growth increases annually at 3%, and the Gross Domestic Product (GDP) keeps increasing that big opportunity for fish (Ministry of Fisheries and Livestock, 2018). Presently, Zambia is said to be a fish deficit country because of the gap that exists between supply, and demand. Currently, there is a decline in fish production from capture fisheries (Ministry of Fisheries and Livestock, 2018).

Other fish species of minor importance include Tellipia (Oreochromis tanganicae) also known as Tanganyika bream, Nkupi commonly known as English fish (*Bulengerochromis microlepis*),

Pande (*Hemibates stenosoma*), and three species of Nile perch commonly known as Pamba and Nyumvi (Smart Zambia, 2022).

In the face of Zambia's recent policies for optimizing the sustainable management of fisheries, their success has been modest in practice (Haambiya et al., 2015). Hence, realizing the full potential of capture fisheries requires a paradigm shift to embrace a new, responsible, and sustainable approach that is more environmentally, socially, and economically effective (Ababouch and Fipi, 2015). This comes at a crucial time when the need for food, and resources from capture fisheries is increasing rapidly to meet the needs of the growing population (Ababouch and Fipi, 2015).

1.2 Socio-ecological Interactions

Components of socio-ecological systems, their interactions in marine fisheries, and the resulting outcome of interactions are not always clear to numerous fisheries stakeholders (Parsram, 2008). The small-scale fisheries for large fish, and shallow reef fish are examples of such complex systems (Parsram, 2008). If stakeholders involved in the governance of such small-scale fisheries had a better understanding of how these complex socio-ecological systems function from a network perspective, then it may be possible to improve the outcome to meet societal goals (Parsram, 2008).

Conversely, the research study "Socio-ecological Drivers and Dynamics on *Limnothrissa miodon"* focused on examining drivers of the reduction of *Limnothrissa miodon* which prevents Kapenta harvesters from engaging in commercial fishing on Lake Tanganyika in Mpulungu District of Northern Province of Zambia (Department of Fisheries, 2014). This study was used as a tool to examine what exactly is the cause of the reduction in catches of *Limnothrissa miodon* looking at the vastness of the Lake. The instance of the reduction of fish species in question was generally recognized when quantities of fish started declining in the recent past (Department of Fisheries, 2014; Shula and Mukuka, 2015; Ministry of Fisheries and Livestock, 2018; World Bank, 2018; Marcel, 2018; National Assembly of Zambia, 2021). Department of Fisheries in Goma, 2012 shows a declining trend (Figure 1.2).

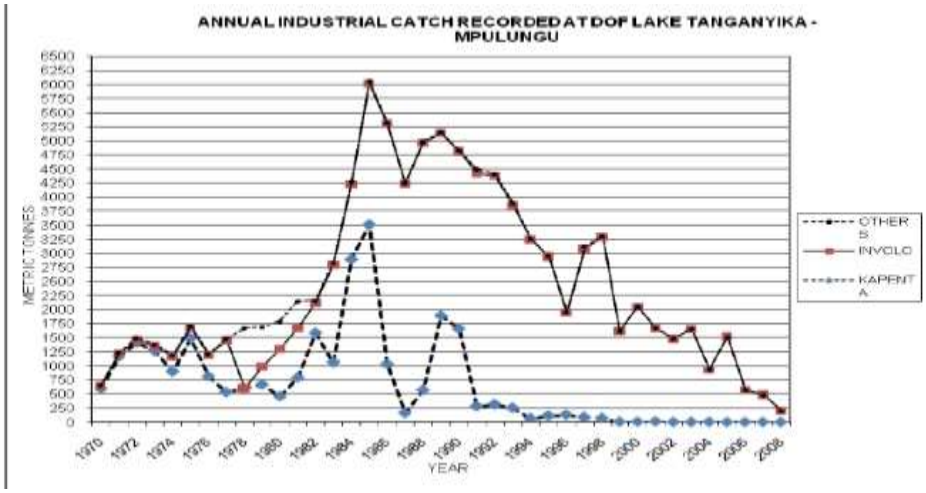

Figure 1.2: The Declining Trends of Kapenta
Source : Goma, 2012

1.3 Statement of the Problem

Admittedly, Mpulungu District is well-known for *Limnothrissa miodon* since time immemorial, and Lake Tanganyika specifically is documented from way back as the 'Reservoir of Kapenta' (Nyirenda, 2017; Department of Fisheries, 2014; World Bank, 2018; KFTI, 2009). Preferably, Lake Tanganyika should have the availability of Kapenta with a possibility of inexpensive prices in markets as this fish species is endemic to the lake. *Limnothrissa miodon* on the lake should display both "direct accessibility" (i.e. unassisted), and "indirect accessibility" suggesting the compatibility with fisher's assistive technology when fishing the resource (Henry et al., 2014). Moreover, the Ministry of Fisheries, and Livestock is mandated to oversee fish sustainability on the lake, and the country as a whole. In this case, the Department of Fisheries identified breeding sites, and no-go areas on Lake Tanganyika for the perpetuity of *Limnothrissa miodon* (Department of Fisheries, 2014; Ministry of Fisheries and Livestock, 2018). Other management aspects initiated by the Department of Fisheries on the lake to sustain the resource includes the prevention of fishers from practising the Kutumpula fishing method, discouraging the use of poison, and mosquito nets when harvesting fish (Department of Fisheries, 2014; Ministry of Fisheries and Livestock, 2018; KFTI, 2009).

The problem is despite the above-mentioned conceited efforts by the Government of the Republic of Zambia to sustain *Limnothrissa miodon* in the country, the compliance level of submission of catch returns among Kapenta fishers on Lake Kariba has reduced, and there is a decline in Catch per Unit Effort (CpUE) from 177 to 72 kg/boat/night (Department of Fisheries,

2014). Additionally, profitable Kapenta fishing on Lake Tanganyika is no longer taking place. Furthermore, it can also be noted that profitable Kapenta fishing companies on Lake Tanganyika have now resorted to purchasing the *Limnothrissa miodon* commodity from semi-industrial fishers, and then process and package it in readiness for markets (Department of Fisheries, 2014). Therefore, the reduction of *Limnothrissa miodon* if not checked on Lake Tanganyika exacerbates the lack of employment, and income for local people, exacerbates unavailability of food, and nutritional security, and forces local people to divert to other livelihoods such as charcoal production. It is worthy it then to note that this study, therefore, examined Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* on Lake Tanganyika, and provided mitigating strategies to sustain the resource on the lake.

1.4 Purpose of the Study

The purpose of this study was to examine Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* on Lake Tanganyika.

1.4.1 Specific Objectives

The study was guided by the following specific objectives;

i. to establish factors of the reduction of *Limnothrissa miodon.*
ii. to investigate the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers.
iii. to suggest strategies that could be used to sustain *Limnothrissa miodon*.

1.4.2 Research Questions

The study was guided by the following research questions;

i. what factors contribute to the reduction of *Limnothrissa miodon?*
ii. what are the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers?
iii. what are the strategies that could be used to sustain *Limnothrissa miodon?*

1.5 Rationale of the Study

1.5.1 Practical Relevance

By and large, the decline of fish in Zambia was brought to the attention of the Department of Fisheries in 2010 (Shula and Mukuka, 2015). Production of fish from capture fisheries is not likely to increase from the current 75, 000 tonnes (Shula and Mukuka, 2015). This phenomenon threatens employment opportunities, food, and nutritional security in the country. This then predicts an urgent need to examine the Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon.* This study, therefore, displayed a deeper understanding of drivers that contribute to the reduction of *Limnothrissa miodon* on Lake Tanganyika. Conversely, population increase has led to the decline of natural resources in natural water bodies, and this occurrence threatens the attainment of ***Sustainable Development Goals (SDGs)*** that looks at ending poverty, and hunger to achieve food security in the country.

1.6 Conceptual Framework

The conceptual framework also illustrates that new governance challenges could result in several pathways of SES changes (Fauchald et al., 2017). At least, three probable consequences could be envisioned; (i) if resource consumers do not react to difficulties, unsustainable harvests may disintegrate the resource system, (ii) resource consumers could put in order the level of the resource system, and adapt to new combined difficulties, for instance, through cross-scale arrangements, and (iii) riparian states could put into practice top-down set of laws to look after resources from local harvests (Fauchald et al., 2017). Figure 1.6 shows the conceptual framework of how exogeneous drivers could impact the dynamics of a socio-ecological system (SES) (Fauchald et al., 2017).

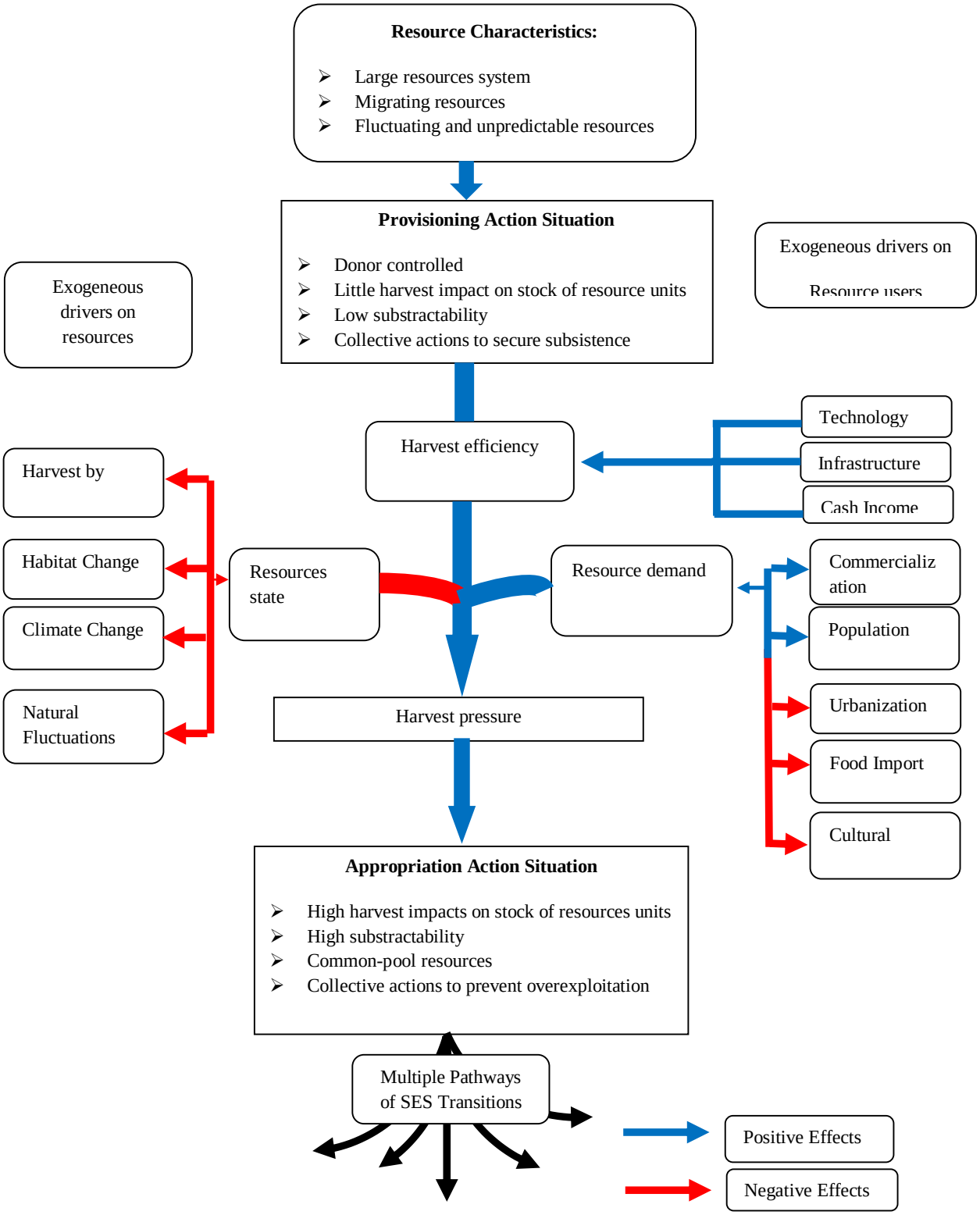

Figure 1.6 : Conceptual Framework
Adapted from: Fauchald et al., 2017

Increased harvest pressure might be because of (i) increased harvest efficiency, and increased resource demand, and/or (ii) intensified harvest efficiency, and decreased state of resources. For as long as an appropriation action situation is introduced, numerous pathways for the SES change are possible, for instance, resources collapse, self-organizing of resource consumers to avoid over-harvest or, governmental top-down regulations (Fauchald et al., 2017).

1.7 Theory of Uncertainty

The research was undertaken using the theory of uncertainty. Quantifiable assessment of the management of fish stock under uncertainty needs a formal framework (Rothschild et al., 2005). Uncertainty, therefore, is the condition or, state in which something, for example, the possibility of a specific outcome is not precisely or, exactly known (Dijk, 2013). Consequently, uncertainty is said to be doubt (Dijk, 2013). The theory was applicable to the study as it intended to engage fishers, and marketeers in more complex, realistic, and problem centered activities aimed at supporting the desired understanding on the topic under discussion (Cohen, 2011; Syabwanta, 2017). Fishers were engaged in one-on-one interviews, and could immense in some undertaking while; solving problems (critical thinking) skills such as applying friendly practices to cop, and adapt to the existing challenges. The research study enhanced the researcher's chances of being involved in society which stimulated the real world situations on how to address the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers (Syabwanta, 2017). According to Nevill (2008), the concept supporting fisheries management over most of the twentieth century hung on assumptions which rarely hold dependably in practice. The evident strain with finding evidence from marine waters is that people do not stay water, and even if people stayed in water, one cannot see very far regards abundance, and quantity of fish species. It is difficult then to get accurate numerical evidence on organism's abundance, and movement (Nevill, 2008). Therefore, marketeers, and fishers could be engaged through involvement in extension services so they understand how fish breed, and getting engaged in knowledge acquisition through pedagogical instruments along the bank of Lake Tanganyika, thereby reducing the pressure, and fishing effort on the lake.

1.8 Definitions of Terms and Descriptions

A *socio-ecological system* describes dynamics, and interactions between society, and ecosystems through social, economic, and ecological processes that influence the state of natural resources.

Drivers are important factors that make essential things happen.

Dynamics are forces or, properties which stimulate growth, development or, change within a system or, process.

The generic name *Limnothrissa miodon* is taken from the Greek *limno* referring to the lake, meaning species' distribution on Lake Tanganyika, and *thrissa*, the Greek term for a kind of anchovy which is utilized as a typical suffix for clupeids.

The name *miodon* is a combination of *mio* which means less or, small, and *don* which refers to teeth, meaning smaller teeth compared to associated species, for instance, *Pellonula vorax.*

Tanganyika is the name of the lake Stanley, H. M (Stanley,1899) came across when he was at Ujiji in 1876; he wrote that locals were not sure about its meaning but he inferred that it meant something like "the great lake spreading like a plain" or, "plain-like lake"

1.9 Organization of the Dissertation

This dissertation is organized into seven chapters. Chapter one encompasses the introduction, statement of the problem, the purpose of the study, specific objectives, research questions, rationale of the study, conceptual framework, theoretical framework, and definitions of terms, and descriptions. Chapter two consists of literature review. Chapter three includes description of the study area, and Chapter four covers methodology as the engine of the study. Chapter Five presents findings, chapter six covers discussion of findings while; chapter seven discusses conclusions, recommendations, and future research topics as generated from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Summary of the Methodology

The research study pursued; (i) factors that contributes to the reduction of *Limnothrissa miodon,* (ii) effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers, and (iii) strategies that could be used to sustain *Limnothrissa miodon*. The case study research design targeted fishers, marketeers, and key discussants. Qualitative method was used to capture attitudes, views, ideas, and opinions of respondents on the reduction of *Limnothrissa miodon.* Snowball sampling, and expert purposive sampling techniques were used to gather data. Questionnaires, Focus Group Discussions (FGDs), and interview schedules were used as data collection instruments (Appendix 2, 4, and 6). Thematic analysis was adopted to get themes, codes, and gave meanings.

2.1.1 Introduction

The chapter illustrated detailed explanations of theories that supported the research study. Included in this chapter were detailed elucidations of policies, and sections of legislation supporting this research work. In this segment, the global status of aquatic life was explained narrowing down to the local status of aquatic life. This section established a wide range of socio-ecological drivers, investigated the consequences of various socio-ecological drivers on fishers, and marketeers, and further explained the sustenance of *Limnothrissa miodon* on Lake Tanganyika.

2.2 Global Status of Aquatic Life

The world total marine catch was 81.2 million tonnes in 2015 and 79.3 million tonnes in 2016 which represents a decline of almost 2 million tonnes (FAO, 2018). The catches of anchoveta (*Engraulis ringens*) by Peru, and Chile are frequently considered, yet greatly unpredictable has seen a 1.1 million tonne decline with other major countries, and species predominantly *cephalopods* that also shows a decline in catches between 2015 and 2016 (FAO, 2018). The declining harvests affected 64% of the 25 top harvesting states but only 37% of the remaining 170 states seem to be stable (FAO, 2018). At present, approximately 80% of global fish resources are well thought-out to be fully depleted, and worldwide fish landings are on the

decline (Henderson, 2016). By analyzing the 15-year time-series (2000 – 2015) of fish harvests for 116 fish species accessed from a commercial-scale 'Dai' fishery, it was revealed then that; (i) 78% of fish species showed some declining harvests over the period, (ii) descending trends in harvests prevailed principally on average to large-bodied fish species that tend to dwell in high trophic levels, (iii) a comparatively constant or, rising trend in a harvest of small-sized fish species, and (iv) a reduction in individual fish weight, and length for numerous widespread fish species (Ngor et al., 2018).

Currently, it has turned out to be widespread knowledge that the world's fisheries resources have been severely depleted. The existing estimate by FAO (Krogseng, 2016) states that over 75% of the world's fisheries resources are completely exhausted, and worldwide harvests have been reducing by 7, 000, 000 tonnes per year since the 1980s (Krogseng, 2016). The exhaustion of fish is unenthusiastically affecting the biodiversity of the marine ecosystem making it more complicated to feed the ever-increasing human population, and ensuing in adverse political, economic, and societal state of affairs (Krogseng, 2016). The world's fisheries resources exhaustion is predominantly challenging as it reduces a resource on which many of the world's poor individuals rely for food, and nutritional security (Krogseng, 2016). The exhaustion of renewable resources is becoming ever more widespread in this present day. Forest cover, for instance, is lost in the tropics, the collapse of fisheries resources, and the rare status of rhinos, and much other flora, and fauna are well-known examples (Eisenbarth, 2018).

2.3 Continental Status of Aquatic Life

On the African continent, the depletion of fisheries resources is having its own share, for instance, Ghana's fish trade deficit is growing, and in 2013, it increased to USD 319, 000, 000 while; fish import grew to USD 373, 000, 000 (Coastal Resources Center, 2018). Fish supply comes from marine capture fisheries, freshwater capture fisheries on Lake Volta, and other freshwater bodies, and aquaculture to meet Ghana's annual fish consumption needs of 720, 000 metric tonnes. The local capture fisheries, and aquaculture production in Ghana to date has not been capable to close the widened gap of 320, 000 metric tonnes (Coastal Resources Center, 2018). The marine capture fisheries production has declined from 420, 000 metric tonnes in 1997 to 203, 000 metric tonnes in 2014. The sign in the reduction of wildlife resources, and

biodiversity are becoming more obvious (Hoof and Kraan, 2017). This is evident as seen from the reduced fish harvests, worsening conditions of coral reefs, and the continued decline in mangroves, and coastal forests. Sea grass beds have been unenthusiastically affected by prawn fisheries (Hoof and Kraan, 2017).

Therefore, it can then be safely said, the reduction of fish in African natural water bodies has reached disastrous levels as numerous, and main fisheries resources are in the reduction mode, and fish species are hard-pressed toward depletion (Daniels et al., 2016). Conversely, and as highlighted by former UN Secretary-General Kofi Annan in the year 2014, Africa Progress Panel Report; grain, fish, money (Daniels et al., 2016), exhaustion of West Africa's fisheries resources have created overwhelming societal, monetary, and human consequences. The livelihood of artisanal fishers is destroyed, an essential basis of protein is lost, and chances for expansion of regional production, and trade are disappearing (Daniels et al., 2016).

2.4 Regional Status of Aquatic Life

In Zambia, there is also evidence of the decline of fish in natural water bodies as indicated by Mukosa (2019) who said that over 36 fish species are on the verge of extinction in Kafue Flats in Monze District of the Southern Province of Zambia. Mukosa (2019) expressed fear that in a few years, all fish species in Kafue flats might be depleted, and there is a serious risk of all fish species reducing in quantity. Fisheries offer great potential for diversification, employment, and poverty reduction. The fisheries sub-sector also provides business opportunities in fisheries, and related industries in the value chain (National Assembly of Zambia, 2021). Depletion of fish stocks affects the livelihood of populations which depends on the fishing value chain (National Assembly of Zambia, 2021). The country's current demand for fish which stands at about 160, 000 metric tonnes, far outstrips fish supply which currently stands at about 120, 000 metric tonnes, making Zambia a net fish importer (National Assembly of Zambia, 2021).

Interacting with fishing communities, fish wholesalers, and indeed fish consumers, it can then be confirmed that quantities of fish in natural water bodies are reducing at a fast rate, and in some cases, the size of fish is also reducing. Therefore, the decline of fish is no longer a threat, but a reality that requires urgent attention (Kiefer, 2017).

Conversely, similar observations were made by Kasambala (2019) who confirmed that there is an alarming rate of depletion of fisheries resources in the country. It was further long-established that the production of fish from capture fisheries is not likely to increase from the current 75, 000 tonnes on average as it started declining in 2010 (Shula and Mukuka, 2015). Currently, Zambia can be said to be a fish-deficit nation because of the gap that exists between supply, and demand (Ministry of Fisheries and Livestock, 2018).

2.5 Local Status of Aquatic Life

The catch and Catch per Unit Effort (CpUE) of certain species like Kapenta has drastically declined (The New Humanitarian, 2009). The dwindling fish stocks on the lake is a matter of serious concern among all riparian states, and admittedly, the Department of Fisheries is not certain if the 350 endemic fish species can be easily found in the waterbody presently (The New Humanitarian, 2009). Additionally, Kapenta on Lake Kariba are depleting at unprecedented volumes (Murimwa, 2020). World Bank (2018) said; this fish species which plays a pivotal role in income generation, food, and nutritional security has its catches reduced on the natural waterbody. *Limnothrissa miodon,* a good fish species, significant, and endemic to the lake shows from recent information that its catches are declining every year (Marcel, 2018).

Additionally, observations of field Kapenta catch records in the Fisheries Annual Report (Department of Fisheries, 2014) show a reduction in the compliance level of submission of catch returns among Kapenta fishers on Lake Kariba. The results also show a decline in Catch per Unit Effort (CpUE) from 177 to 72 kg/boat/night (Department of Fisheries, 2014). The Fisheries Annual Report further showed that profitable Kapenta fishing on Lake Tanganyika is no longer taking place (Department of Fisheries, 2014). It can then also be noted that profitable Kapenta fishing companies on Lake Tanganyika have now resorted to purchasing the Kapenta commodity from semi-industrial fishers, and then processing, and packaging it in readiness for markets (Department of Fisheries, 2014).

2.6 Multiple Socio-ecological Drivers

The global scale, and complication of ecological change have triggered attempts to understand associations amid societal, and ecological processes across a variety of academic disciplines

(Cote and Nightingale, 2011). It is pertinent then to appreciate human sources of ecological change, and to do this, it is vital to understand dynamic forces motivating human actions. Dynamic forces are fundamental drivers that control, and direct human activities (Petrosillo et al., 2017). These drivers either directly or, indirectly result in a change in ecosystems which can disintegrate ecosystem means to present goods, and services to humans (Petrosillo et al., 2017).

At the same time as humans impact, for instance, fishing that distorts both marine, and freshwater food web compositions, and body size, conditions of the world's essential tropical inland fisheries resources remain unknown in most cases (Bustamante et al., 2018). Findings of sustained fish production but the distorted distinct composition is steady with a prediction from topical indiscriminate theory, and give caution to Fisheries Resources Conservationists, and Managers (FRCM) that species-rich levels worldwide are affected by serious indiscriminate fishing demand (Bustamante et al., 2018). Capture fisheries, equally, are undergoing various setbacks from anthropogenic activities, namely, population growth, habitat destruction, pollution, invasive species introductions, overfishing, and climate change (Bustamante et al., 2018).

Illegal fishing occurs when fishing boats or, harvesters manoeuvre in violation of the policy of a fishery (Christensen, 2014). This would apply to fisheries that are under the authority of a coastal state or, to high-sea fisheries regulated by Regional Fisheries Management Organizations (RFMO) (Christensen, 2014). According to FAO in the Fisheries, and Aquaculture Department (FAD), illegal fishing has led to losses anticipated at USD 23, 000, 000, 000 annually with around 30% of illegal fishing global occurrences in Indonesia alone (Christensen, 2014). The causes of Illegal, Unreported, and Unregulated (IUU) fishing are comparable to those behind various additional forms of intercontinental ecological crime. Pirate fishers have a physically powerful financial incentive, various fish species, mostly those that have been overexploited, and are, therefore, in short supply of high monetary value (Christensen, 2014).

Overharvesting or, overexploitation takes place when humans harvest extra of a natural resource than they can replenish on their own (Bustamante et al., 2018). This unsound activity threatens living organisms, and can damage ecosystem services by plummeting species populations below natural self-sufficient levels, and unsettling ecosystem function, and species interconnection (Bustamante et al., 2018). Overharvesting can take place in hunting, fishing, logging,

groundwater mining, overgrazing, and gathering of wild plants, and animals for medicine, decoration, for the pet trade (Bustamante et al., 2018). Harvested species are used as food, building, and other industrial materials such as medicine, fibre for clothing, and ornamental substances in addition to other societal, and cultural elements. Increasing human population, escalating income, consumer demand, growing markets, and enhanced technology all leads to the overharvesting of living organisms (Bustamante et al., 2018). Individuals, communities or, corporations that have open, and unfettered access to community supplies like forests, aquifers, fisheries, and grazing lands can spoil a shared resource to make most of the short-term proceeds until it ultimately becomes unavailable for multitudes (Hardin, 1968). Harvesting natural resources is an indispensable part of the livelihoods, and economies of every state (Bustamante et al., 2018). When individuals act in their selfish interests, they are inclined to devour as much of an insufficient resource as possible leading to overharvesting, and in some instances, extinction or, resource depletion is the outcome (Bustamante et al., 2018).

As for marine waters, the most important cause of the decline of fish in the marine environment is overfishing (Bustamante et al., 2018). With population growth, and escalating income, the need for seafood continues to go up for both human consumption, and feed for livestock, and aquaculture (Bustamante et al., 2018). Fishing remains a major source of food, and employment for millions of individuals in America, for example, an important element in regional economies. About 2.4, 000, 000 fishers, and 10% of the world's powered fishing vessels are in natural waterbodies (Bustamante et al., 2018). Thus, overfishing, and habitat degradation have led to the decrease of innumerable large marine predator species from the majority of the world's oceans (Valdivia et al., 2017).

Wana (2016) also said, climate change exhibits noteworthy intimidation to fisheries in addition to countless other simultaneous pressure, for instance, overfishing, habitat degradation, pollution, and introduction of new species as alluded to earlier (Wana, 2016). If individuals are encountering global warnings with an effect on ocean ecology, overfishing may additionally fortify the effects of change in ecosystem structure, and invasive species (Wana, 2016). Climate change will impact a variety of biotic elements that are firmly connected to the production, and distribution of fish species' population, and these climate-driven biotic changes will probably be different amid an open ocean, shelf seas, and coastal waters (Wana, 2016). Although climate

change outcomes are frequently difficult to differentiate from the damage caused by overfishing, and pollution, these climatic changes are having effects on aquatic ecosystems (Wana, 2016). Medhi et al (2018) alluded; climate change is also contributing to problems of inland fish population instability. Correspondingly, chronologically large numbers of numerous fish species have been found to have a substantial relationship with pragmatic climatic conditions (FAO. 2001). Changes in the main productivity of autotrophs in lakes, rivers, and oceans can affect marine, and freshwater food webs (FAO, 2001).

2.7 Consequences of Socio-ecological Drivers

However, in comparing with regions that greatly manage fisheries resources, regions with underdeveloped fisheries supervision have on average threefold higher harvesting rates, and half a great quantity as assessed resources (Thurstan et al., 2010). Available proof recognized that regions without an assessment of large quantities of fish have minute fisheries management, and fisheries resources are in a poor profile (Thurstan et al., 2010). Through the 1970s, and 1980s, it became apparent that numerous fisheries were overcapitalized, and that fish quantities were exhausted to low levels due to their state of unmanaged commons (Thurstan et al., 2010). The major exhaustion in the number of fisheries was practical, for instance, most herring resources of the Northeast Atlantic area were exhausted noticeably, and collapsed throughout the late 1960s, and near the beginning of the 1970s (Thurstan et al., 2010). In addition, the Peruvian anchoveta, for instance, was exhausted in the 1970s, and Newfoundland as another example whose Cod fishery collapsed (Thurstan et al., 2010). This collapse set the phase for major concerns than before on the status of fisheries resources, and a broad range of events to overturn exhaustions, together with intensifications of a lawful basis for addressing overexploitation of fish in some countries (Thurstan et al., 2010). The strength, and efficiency of these commitments vary highly by region with some states worsening to lessen overfishing with others implementing key regulatory changes (Thurstan et al., 2010). Exhaustions of fisheries resources became a subject matter of high-status technical publication, media reporting, and public attention in the 1990s, and 2000s when worldwide fisheries disaster observations were recognized (Thurstan et al., 2010). The collection showed that whilst two-thirds of resources were below fisheries supervision biomass targets, the majority of the biomass was steady with exhaustions happening in some regions, and increases taking place in others, and that half of the resources below target

abundance had utilization rates that would allow transformation to the target (Thurstan et al., 2010). They recommended a credible connection between fisheries resource abundance, and management measures (Thurstan et al., 2010).

Indirect pressure of overfishing includes habitat degradation from destructive fishing gears and pollution, for instance, plastic, and oil, and overfishing has already resulted in habitat loss (Pape et al., 2017). Pressure, and stressors decrease fish stocks abundance, and marine ecosystem health (Pape et al., 2017). Climate change, and overfishing are working together to accelerate the decline of ocean health putting marine ecosystem goods, and services provided to society at risk. The declining fish stocks leads to frequent population collapse with fish reducing population levels by a great magnitude (Pape et al., 2017). As affluent nations increasingly demand high-value fish, fisheries have become privatized, making it difficult for people in developing nations to compete with global commercial fishing fleets (Jones, 2013). As a result, issues of food scarcity, and loss of employment will continue to affect 2.6, 000, 000, 000 people that live in coastal communities, and developing nations that greatly depends on fish for survival (Jones, 2013). With the globalization of fishing industries, depleted fisheries resources have become a prominent food security issue that affects people on every continent, and requires multilateral cooperation, and compliance to secure the livelihood of millions, and prevent the collapse of the fishing industry (Jones, 2013). If this current trend continues, experts agree that the viscous cycle of declining fish stocks will undoubtedly result in the collapse of aquatic ecosystems, and the collapse of economies on a global scale. However, as the demand for seafood increases, so will the price (Jones, 2013). This will result in billions of people being unable to afford seafood due to increasing demand in wealthy nations, and vast commercial fleets that will out-compete local subsistence fishermen (Jones, 2013). The global catch is already unstable, and unequally divided among nations of the world, and will only be exacerbated as fish stocks are decimated (Jones, 2013).

Ultimately, this negatively affects local economies because they overexploit already vulnerable and top-predator fish stocks resulting in issues of food scarcity, and loss of livelihood in future. Another issue is the lack of incentives to protect this valuable industry (Jones, 2013). Fish are what are known as common-pool resources, as a result, poverty increases as they are overharvested, the availability of fish, and marine resources decline, and people begin exploiting

other natural resources to replace the loss of income (Jones, 2013). Unfortunately, most heavily exploited, and highly profitable fisheries may never have the opportunity to recover before they vanish forever (Jones, 2013). Although the developed world is most responsible for the unstable state of global fish stock due to its insatiable appetite for fish, it is the world's poor people that will face the burden of these socio-economic, and ecological disasters (Jones, 2013).

Without seafood, billions of poor people will be plagued with issues of food scarcity, and malnutrition, and will lose that sense of economic security that fishing may have provided them (Jones, 2013). The fishing industry has that great importance to developing economies, and therefore, must be protected to prevent the collapse of global fisheries, and possibly devastating effects on the global ecosystem, and the global economy (Jones, 2013). Since the 1980s, fish stocks have been overexploited, ecosystems have been modified, and economies that once thrived from fish export have crashed (Jones, 2013). As a result, international tensions have mounted due to competition over resources, and much debate has been on how to properly manage fisheries, and trading of goods (Jones, 2013). Human pressure is increasing, and numerous ecosystems are affected by cumulative effects from different sources of disturbances (Thrush et al., 2016). Consequently, the results of not sustaining *Limnothrissa miodon* will then result in Lake Tanganyika becoming unsustainable at the aquatic ecosystem level (Coll et al., 2008).

Moreover, depleted fish stocks have put fishermen out of work, and the fear is that in future there will be no fishermen left (Johnson, 2019). The current situation creates local societal challenges such as unemployment, poverty, lack of health, lack of educational opportunities, frustration, and societal tensions on the local population losing their traditional way of income generation, and livelihood (Johnson, 2019). Decreasing fisheries resources that have been a source of employment in many West African countries, for example, forcing young people to migrate to large cities or, neighbouring countries where work is hard to find (Johnson, 2019). As exclaimed by respondent's experience (Johnson, 2019) working in local fishing communities in Senegal said, families no longer have any resources, and income to afford their children's education, and healthcare, and are living under inhuman conditions which depends on foreign exploitation of these people, and areas resources (Johnson, 2019). This leads to destructive consequences for people's livelihood, and forces some to get involved in mischievous activities in their struggle

for survival; activities like crime or, simply leaving their traditional villages (Johnson, 2019). Fishing communities in many African countries are known to be relatively immobile with sustainable living conditions (Jones, 2013). This fact has, however, changed dramatically since the appearance of new international fishing actors in their waters (Jones, 2013). As mentioned earlier, decreasing fishing opportunities influence various aspects of the local community's sustainable lifestyles, and living conditions forcing many youths to migrate to urban centres in search of employment (Jones, 2013).

Countless young West Africans end up as "illegal migrants" in other countries (Jönsson, 2019). However, migration to Europe is for many a very costly, and dangerous process with major risks to migrant's lives (Jönsson, 2019). Therefore, the desperate endeavours of numerous people to tackle poverty, and the destruction of their traditional life opportunities force them to move to both urban areas in major West African cities and Europe (Jönsson, 2019). Besides, the effects of not sustaining fish species culminate in reduced fish harvest as there are always worsening conditions of coral reefs, and the continued decline in mangroves, and coastal forests. Sea grass beds are also unenthusiastically affected by prawn overfishing (Hoof and Kraan, 2017).

Exhaustion of fisheries resources can create overwhelming societal, monetary, and human consequences (Daniels et al., 2016). Additionally, the livelihoods of artisanal fishers are destroyed by unsustained fish species, and an essential basis of protein is also lost, and chances for expansion of regional production, and trade disappear (Daniels et al., 2016). Furthermore, present rates of fish extraction are driving numerous fish species toward disappearance whilst; jeopardizing the livelihoods of artisanal fishing communities across a wide group of states (Daniels et al., 2016). Irrefutably, the sad realities of not protecting the fish species in question have led to the predicament of the tragedy of the commons referred to in an article by Garrett Hardin that was initially published in the journal of Science (Hardin, 1968). Pivotal to Hardin's paper despite publishing it several decades ago is an instance which is a helpful story for understanding how the decline of *Limnothrissa miodon* on Lake Tanganyika has occurred (Hardin, 1968).

2.8 Sustenance of *Limnothrissa miodon*

It may also be desirable to introduce regulations of closed areas, and closed seasons, and thus, help resources to recover (Bwathondi et al., 2001). Consequently, efforts should be made to access indigenous knowledge to support the identification of closed areas, and possibly practicalities of implementing such action has to be evaluated. High priority, and immediate objectives must be given to regulating fishing efforts (Bwathondi et al., 2001).

To realize these needs, some Framework Directives (FD) should be issued on strategies for the Freshwater Environment (FE) which should then be considered in Zambia when issuing Fisheries Laws (FL) (Tursi et al., 2015). The Zambian Directive (ZD) should be based on an integrated approach, and aim to become an environmental pillar of the Future Freshwater Policy (FFP) of the country (Tursi et al., 2015). The directive should set the goal of Good Environmental Status (GES) for the freshwater water body for member states to reach the goal since this lake is shared with other riparian states (Tursi et al., 2015). To reach GES, each member state surrounding Lake Tanganyika has to develop a Freshwater Strategy (FS) which must be agreed upon with all neighbouring member states (Tursi et al., 2015). To avoid the loss of endemic species on the lake, there must be a fundamental goal currently not only for the Freshwater Framework Directive (FFD) but also for other riparian states. Keeping biodiversity protected must be a fundamental need to reach GES for freshwater resources on Lake Tanganyika (Tursi et al., 2015).

Freshwater Protected Areas (FPA) should represent a vital component in assuring the long-term protection of resources, and ecosystem services (Tursi et al., 2015). To ensure that biodiversity is sustainable, the human elements, and tight association amid the coastal freshwater system, and the cultural, collective, and Economic Framework of Local Communities (EFLC) must not be overlooked (Tursi et al., 2015). The biological value of FPA must become secondary if the economic, and societal situation of the region is not taken into consideration (Tursi et al., 2015). Moreover, the structure should try to make certain, sustainable consumption of freshwater goods, and services through to systems approach in running human behaviour, for instance, a line of administration which sees human communities as an essential part of aquatic ecologies, and systems which rule these should prevail (Tursi et al., 2015).

A fishing ban, and suspension of freshwater fishing must be fully adopted on the lake to save fisheries resources (Huang and He, 2019). Besides, restraining fishing gears, all freshwater fishing operations should from time to time be suspended say two to three months during the fishing ban period each year, and diverse breeding sites that have various suspension policies (Huang and He, 2019). In the intervening time, the local strata in the coastal regions should also be closing all stake net fishing on the lake for not less than two months during the fishing ban annually (Huang and He, 2019). It can then be a vital direction for Zambia's coastal, and inland fisheries administration to bring in a Right-based Fishing System (RbFS) (Huang and He, 2019). The worldwide groups of people attach great significance to Right-based Fisheries Management (RbFM), and United Nations Food and Agriculture Organization (UNFAO) organizes precise seminars concerning this subject annually. The beginning of the Right-based Fisheries System (RbFS) in Zambia can inspire fishers, and fish traders to conserve fisheries areas, and their resources (Huang and He, 2019). Globally, the world has universally observed overharvesting behaviour, and has seen a reduction tendency of fisheries resources, therefore, Lake Tanganyika communities must be increasingly aware of the significance of FM (Huang and He, 2019). It must be proposed; a new order of freshwater fisheries resources must be established by the Department of Fisheries (DOF) with a growing demand for efficient management of fisheries resources on the lake. DOF needs to have superior accountability for FM, increasing systems, and standards concerning FM (Huang and He, 2019). The flag state responsibility must be highly emphasized in its national FM. All countries surrounding the lake must have an obligation to put up fishing licenses, and registration systems, perfect counting, collection, storage, and habitual swap system concerning fisheries data, and increase the training system for fishing crews (Huang and He, 2019). The Zambian scholars working in Fisheries Management Research (FMR) should have their attention devoted to Philosophies, and Developmental Directions (PDD) towards Zambia's Capture Fisheries Management (ZCFM) from time to time, and should be accountable to Fisheries, and Ecosystem-based Fisheries Management (FEbFM), and should be the centre of linked future research. Therefore, there are currently some precise FMR questions that needs to be answered (Huang and He, 2019).

It is in this context that the Government of the Republic of Zambia (GRZ) should change management strategies, and bring in stakeholders through community involvement on Lake

Tanganyika by forming Beach Management Units (BMUs). Community involvement in the management of Lake Tanganyika fisheries will see a general improvement in fish catches (Njiru et al., 2017).

Other numerous regulatory actions are available to control overfishing, and these measures comprise fishing quotas, bag limits, licensing, closed seasons, size limits, and the formation of freshwater reserves, and other freshwater-protected areas (Winder, 2018). To fish sustainably, quotas needs to be altered annually to account for fish populations. Fisheries scientists should choose the most favourable amounts of fish, for instance, Total Allowable Catch (TAC) to be gathered in a certain fishery (Winder, 2018). The choice considers carrying capacity, restoration rate, and future value. Under Individual Transferable Quotas (ITQ), harvesters of a fishery are given civil rights to a proportion of the TAC that can be harvested annually. These quotas can be harvested, sold, leased or, bought allowing the least-cost boats to be utilized (Winder, 2018).

Avoiding fishing in spawning areas may allow fisheries resources to reproduce by giving adults a chance to propagate (Winder, 2018). Aquaculture is another copying measure which involves the farming of fish in captivity. These elements efficiently privatize fisheries resources, and create inducements for farmers to preserve their resources as it also reduces ecological impacts (Winder, 2018). Conversely, farming carnivorous fish, for instance, cichlids do not forever reduce pressure on capture fisheries, since carnivorous farmed fish are typically fed on fish meal, and fish oil extracted from wild forage fish (Winder, 2018). Fish farming rates keep on growing whereas; capture harvest remains steady, therefore, fish farming can enclose the entire breeding cycle of fish with fish being bred in captivity (Winder, 2018). There is also a need to create an awareness of overfishing, and effective mitigation measures should be efficient in FM (Winder, 2018). Civilizing preparedness of the set of laws can improve compliance. Additionally, creating community preparedness for the ecological effects of fishing could lead to fisher's willingness to engage in fishing practices like Catch and Release (CR) (Winder, 2018).

2.9 Gaps in Literature

Socio-ecological components and interactions change the biological community's structure and food chain, and may have negative socio-ecological consequences. Almost all the water body's threats are linked to socio-ecological interactions (Niyoyitungiye, 2020). Consequnetly, the lack

of education on resource conservation, socio-ecological drivers, and interactions contributes to environmental damage, and habitat destruction in water bodies. This gradual increase in demographic pressure forced changes to water bodies (Niyoyitungiye, 2020). Therefore, socio-ecological interactions are a common feature along coastlines in water bodies which necessitates the decline of fish. Although common, the socio-ecological drivers of *Limnothrissa miodon* are not thoroughly understood (Niyoyitungiye, 2020). To address this gap, the study explained the causes of the reduction of aquatic resources. The basin of Lake Tanganyika is essential as parts of the landscape play an important role in the sustainable development of the region and linking it to ecosystem services, and the livelihood of local people (Niyoyitungiye, 2020). On the other hand, the effects of human and natural drivers on key landscape characteristics of the lake basin may be critical for ecosystem resilience with some functional aspects still not critically understood (Niyoyitungiye, 2020). Therefore, this dissertation reviewed the scientific literature on socio-ecological drivers and dynamics of *Limnothrissa miodon* seeking to establish factors that contributes to the reduction of *Limnothrissa miodon,* effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers, and strategies that could be used to sustain *Limnothrissa miodon*. Equally, studies from innumerable aspects of socio-ecological drivers found in the literature are direct, and natural drivers, consequences of human decisions, and drivers of an anthropogenic nature (Bustamante et al., 2018). Particularly, the effects of these drivers on communities, and biodiversity were reviewed. In contrast, management plans, and socio-ecological drivers, and interactions of the decline of fish in previous studies were not comprehensively done as much as the consequences of human decisions on Lake Tanganyika.

2.10 Synopsis of the Missing Gap

i. Thorough debates were not done on socio-ecological drivers, and interactions that takes place between society, and the aquatic environment (Marcel, 2018; Department of Fisheries, 2014; World Bank, 2018; National Assembly of Zambia, 2021; Ministry of Fisheries and Livestock, 2018) precisely on Lake Tanganyika of Mpulungu District of the Northern Province of Zambia.

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA

3.1 Introduction

This segment concentrated on the spatial account of the study area where the research problem was based. This section explained the population of the district and the Lake Tanganyila drainage system (Smart Zambia, 2022).

3.2 Location

The district shares international borders with Tanzania and district borders with Mbala District in the east, Mporokoso District in the south and Nsama District in the south-west. Mpulungu district was established in 1997 under statutory instruments No. 118 and 127 of 1997 (Smart Zambia, 2022). Before its establishment, it was a sub-district under Mbala since 1927 (Smart Zambia, 2022). The district is 1008 km from Lusaka, the capital city of Zambia, and 210km from Kasama the provincial capital of Northern Province, and 38km from Mbala which is the nearest district. The district covers a total land magnitude of about 10, 170 square km² (Smart Zambia, 2022).

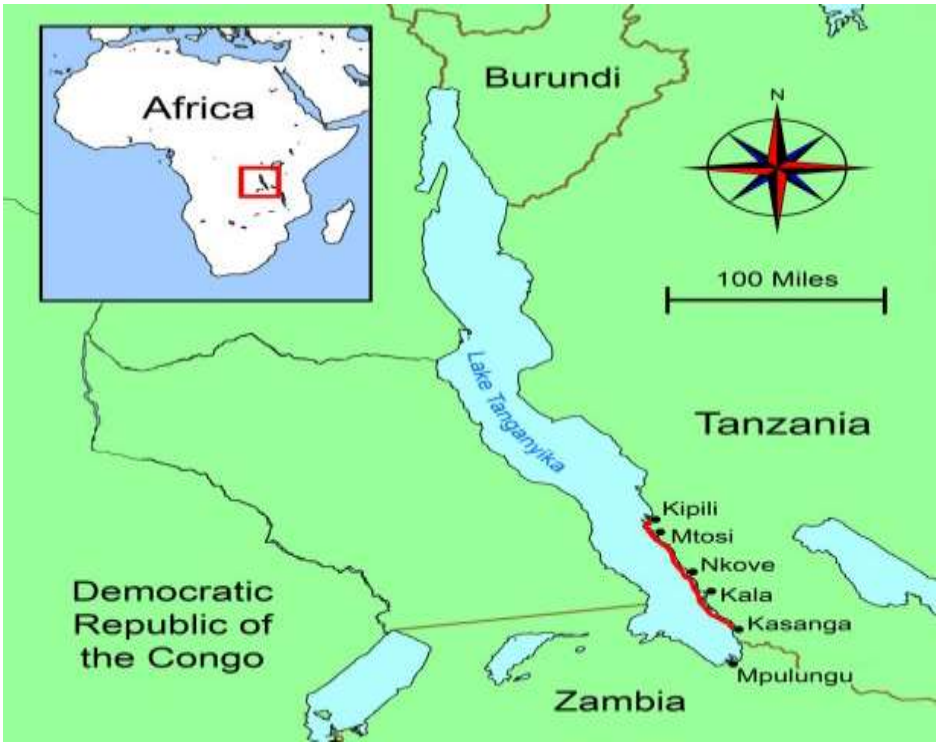

Figure 3.2: Map of Lake Tanganyika
Source*:* Small Boats Magazine

3.3 Population of Mpulungu District

According to the population census of 2018, the population of Mpulungu District stands at 153,564 with about 50.9% females and 49.1% males, and an estimated growth rate of 3.8% and, a population density of 9.6 persons per square kilometer (Smart Zambia, 2022).

3.4 Lake Tanganyika Drainage System

Lake Tanganyika is one of the Great Rift Valley lakes (Smart Zambia, 2022). Its origin is perceived to date as far back as nine to twelve million years ago. It is the deepest fresh water body in Africa, and the second deepest in the world after Lake Baikal of Russia (Smart Zambia, 2022). Tanganyika is one of the largest lakes in Africa, and the second biggest lake considering the area after Lake Victoria. Mpulungu District has two islands on Lake Tanganyika and these are Mutondwe (Crocodile Island), and Mbita Island (Smart Zambia, 2022). Lake Tanganyika is part of the East African Rift which is part of the even larger geological trench which stretches out from Lebanon to Mozambique, and is referred to as the Great Rift Valley (Niyoyitungiye, 2020). The borders of four countries that meet at the lake include Burundi, the Democratic

Republic of the Congo (DRC), the Republic of Tanzania, and the Government Republic of Zambia (Niyoyitungiye, 2020).

3.5 Selection Criteria of the Study Area

Mpulungu District is well known for *Limnothrissa miodon* and Lake Tanganyika especially is acknowledged as the 'Reservoir of Kapenta' (Nyirenda, 2017; KFTI, 2009; Department of Fisheries, 2014). Perfectly, Lake Tanganyika should have *Limnothrissa miodon* at its disposal with prospects of reasonable prices in markets as this fish species is endemic to the lake. On the other hand, the reduction of *Limnothrissa miodon* has made this commodity exhibit skyrocketing prices as it is becoming inaccessible, and unavailable to fishers on the lake and marketeers in the country. Additionally, due to its inaccessibility, and unavailability, commercial Kapenta fishing on Lake Tanganyika is no longer taking place (Department of Fisheries, 2014; Marcel, 2018; World Bank, 2018).

Furthermore, it can also be noted that profitable Kapenta fishing companies on Lake Tanganyika have now resorted to purchasing *Limnothrissa miodon* commodities from semi-industrial fishers, then processing, and packaging it in readiness for markets (Department of Fisheries, 2014). Therefore, the district was chosen for the study area because Lake Tanganyika is well known for *Limnothrissa miodon* since time immemorial, and Mpulungu District is particularly famous from way back as the 'basin for Kapenta'. Moreover, *Limnothrissa miodon* is endemic to Lake Tanganyika, hence fishers, marketeers, and fish traders call it Mpulungu in other cities, and it is perceived as such by many in the country as its local name.

However, it is significant to note that *Limnothrissa miodon* is viewed as a species of economic importance in the Mpulungu District of the Northern Province of Zambia. This study area provided the best information, and essentially addressed the problem by increasing awareness, and knowledge among fishers, and marketeers, and the strategies to sustain *Limnothrissa miodon*. Additionally, it was easy to collect data from selected respondents because fishers, and marketeers were vested with experience, and knowledge on drivers that contribute to the reduction of *Limnothrissa miodon* as they have been in this business, and/or area for a good number of years.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

This chapter vitally explained the suitability of methods, and procedures relevant to the research study whose approach was used to respond to research questions. Methodology in this study was seen as an engine in the whole process of data collection, presentation, and interpretation of findings. The chapter elaborated on, and justified data collection instruments. This chapter, consequently, explained the data source, and analysis. In conclusion, explanations in this chapter concluded with ethical considerations.

4.2 Pholosophical Orientation

This study adopted the constructivism paradigm, and emphasized the importance of multiple measures, and observations (Jia, 2010). The constructivism learning philosophy is the additional development for behaviourism that arrived at cognitivism (Jia, 2010). According to its educational philosophy: knowledge is tentative; the learning procedure of knowledge is also the construction process of information; scholars are the key body of the learning activity, and they construct knowledge in their imagination; teachers are collaborators, and drivers for scholars constructing knowledge (Jia, 2010). Constructivism was adopted in this study to get constructed knowledge on Socio-ecological Drivers and Dynamics of *Limnothrissa miodon* through sharing perceptions, experiences, and observations with respondents. This was based on the idea that fishers, marketeers, and key informants actively make their own constructed knowledge on drivers that contribute to the reduction of *Limnothrissa miodon*, and that this reality is determined by their experiences. Fishers, marketeers, and key informants use their constructed experience to know, and understand drivers that contribute to the reduction of *Limnothrissa miodon*. Eventually, everyone's individual constructed experience makes their understanding of the reduction of *Limnothrissa miodon*.

4.3 Research Approach

This study used qualitative method to capture attitudes, views, ideas, and opinions of respondents (Bryman, 2014). Qualitative research method in this study was selected as opposed to

quantitative or, mixed method since there is no disaggregated Kapenta production information related to Lake Tanganyika. Therefore, with the qualitative research method, the researcher got a better understanding of the topic under discussion through first-hand experience, truthful reporting, and quotations of actual conversations. The researcher understood how participants derived meaning from marketeers, and fishers as well as key informants of the *Limnothrissa miodon* status, and how meanings influenced their behaviour toward this resource.

4.4 Research Design

This was a case study research, and it provided detailed, and rich qualitative information with an understanding that *Limnothrissa miodon* is unique on the lake due to its endemism on Lake Tanganyika (Yin, 2014). Hence, marketeers, fishers, and key informants were selected as they have stayed, and/or studied, sold, and/or harvested *Limnothrissa miodon* for a long time. The method provided an in-depth understanding of participants' perceptions of Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* (Yin, 2014; Syabwanta, 2019). This case study strategy enabled the researcher to closely examine data within a specific context (Zainal, 2007). Additionally, the case study in its true spirit explored drivers that contribute to the reduction of *Limnothrissa miodon,* and the effects of the decline of *Limnothrissa miodon* (Zainal, 2007). Therefore, this study investigated contemporary real-life phenomena through detailed contextual analysis of several events or, conditions, and their relationships (Yin, 2014; Zainal, 2007).

4.5 Population

The target population for the study was one hundred, and twenty-four (124). The respondents included ninety two (92) fishers, twenty four (24) marketeers, and eight (8) key informants. The study target population was further segregated as follows; thirty two (32) fishers in Kasasa fishing village, thirty (30) fishers in Musende fishing village, thirty (30) fishers in Kabatwe fishing village, twenty four (24) marketeers in Ngwenye market, and eight (8) key informants. In this study, more representative data was taken from the southern part of Lake Tanganyika because of some perceived experiences on the reduction of Kapenta as fishing of *Limnothrissa miodon* also takes place there. Consequently, the study targeted fishers, marketeers, and key informants.

4.5.1 Sampling Procedure

Specific respondents the researcher believed would give the most valuable information were selected for interviews through expert purposive sampling. Therefore, key informants that possessed knowledge on fisheries related topics, and were willing to share factors, and effects of the decline of Kapenta were identified in the population. The key informants that suited the researcher's study focusing on a relatively small sample were selected and interviewed one after the other. Expert Purposive sampling was chosen as it focused on relatively small samples to gather subjective opinions on causes of the decline of Kapenta on Lake Tanganyika. The retired former fisheries staff hailing from Mpulungu District but worked from Southern Province directed the researcher to respondents that provided the most important data through snowball sampling. Eventually, the researcher interviewed respondents he easily accessed from the larger population. The potential subjects within fishing villages, and the market were identified, the former fisheries staff contacted potential subjects, the subjects were asked as samples were identified in the study area. The subject referals were encouraged to participate in the study, and were evaluated using discriminative sampling, and this was repeated until the research reached saturation at the desired sample size of one hundred, and twenty-four (124) samples. Expert purposive sampling was selected as it was believed that a selected few respondents were best suited to answer research questions. Snowball sampling was chosen for sampling as there were no readily available samples in the frame. Additionally, the population in the study area was hard to access or, locate due to the nature of their job as fishermen and traders.

4.5.2 Sample Size

Data saturation was a key driver for determining the adequacy of sample size of one hundred, and twenty-four (124) participants (Aguboshim, 2021). The respondents included ninety two (92) fishers, twenty four (24) marketeers, and eight (8) key informants. The study target population was further segregated as follows; thirty two (32) fishers in Kasasa fishing village, thirty (30) fishers in Musende fishing village, thirty (30) fishers in Kabatwe fishing village, twenty four (24) marketeers in Ngwenye market, and eight (8) key informants.

4.6 Data Collection Tools

The process of gathering and measuring information on variables of interest in an established, and systematic fashion enabled the researcher to answer stated research questions to evaluate outcomes (Kabir, 2016). The data collection components of research are common to all fields of study including humanities, business, physical, and social sciences (Kabir, 2016). While methods vary by discipline, the emphasis on ensuring accurate, and honest collection remains the same (Kabir, 2016). The goal for all data collection is to capture quality evidence that translates to rich data analysis and allows the building of convincing, and credible answers to questions that have been posed (Kabir, 2016). Irrespective of the field of study or, preference for defining data, be it quantitative or, qualitative, accurate data collection was essential to maintaining the integrity of the research (Kabir, 2016). This was to do with both the selection of appropriate data collection instruments, and delineated instructions for the correct use to reduce the likelihood of errors occurring (Kabir, 2016). Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* used primary data collection tools (Appendix 4, 5 and 6).

4.6.1 Primary and Secondary Data

The researcher used questionnaires (Appendix 4) to collect data which was a list of questions that had both open-ended, and close-ended questions, and respondents gave answers (Kabir, 2016). On the other hand, interviews (Appendix 2) were also used for data collection, and these were face-to-face conversations with respondents (Kabir, 2016). Therefore, primary data in the study included interviews (Appendix 2), Focus Group Discussions (FGDs) (Appendix 6), observations (Appendix 11), and photographs (Appendix 6). In this study, primary data collection tools included Unstructured Interviews (Appendix 2), Focus Group Discussions (FGDs) (Appendix 6), for instance, General Respondents Questionnaires (Appendix 4), and Key Informants Data Collection Tools (Appendix 5) were used to collect data from chosen respondents (Syabwanta, 2019). Secondary data was collected from published journal articles, reports, dissrtations, newspapers, and magazines and was edited for literature review.

Table 4.6.1: Data Collection Tools

Data Collection Tools			
No.	**Collection Tool Types**	**Collection Methods**	**Description**
01.	Primary data collection tools	Unstructured interviews	Guided, and unguided schedules
		Focus group discussions (FDGs)	Note-taking
02.	Secondary data collection tools	Documents, reports, journals, newspapers, and theses	Reading, and reviewing

Source *:* Syabwanta, 2019.

4.6.1.1 Unstructured Interviews

The right respondents were recognized for interviews (Oxfam, 2019). Interviews were set (Appendix 2), and introductions were done followed by an explanation, and/or reading, and/or interpretation of the consent form (Appendix 7 and Appendix 10) by the research assistant to respondents (Cohen and Crabtree, 2006). The conversation began on the research topic, the interviewer, and respondents later engaged in formal interviews (Appendix 2). The interviewer developed, and used an interview guide (Appendix 3). This was a list of questions, and topics that were covered during conversations (Cohen and Crabtree, 2006). The interviewer followed the laid down guide (Appendix 2) but was able to follow topical paths in conversations that strayed from the guide when he felt this was suitable (Cohen and Crabtree, 2006). The unstructured interview guide (Appendix 2) provided a perfect set of instructions for the principal investigator, and provided dependable, and equal qualitative data (Cohen and Crabtree, 2006). There was an inclusion of open-ended questions to follow pertinent subjects that strayed from the interview guide (Appendix 2), though, still, the researcher provided the chance for classifying new ways of seeing, and understanding the subject at hand (Cohen and Crabtree, 2006). The interviewer had a paper-based interview guide (Appendix 2) that he followed, and comprised of open-ended questions (Cohen and Crabtree, 2006). The researcher took notes during interviews, and later transcripted these notes for analysis (Appendix 3). The researcher settled for unstructured interviews because questions were prepared ahead of time. The interviewer was prepared, and appeared competent during interviews (Cohen and Crabtree, 2006).

4.6.1.2 Focus Group Discussions

The focus group discussions (FDGs) (Appendix 6) were used to collect data from fishers, marketeers, and key informants as they were asked to shade more light on their opinions on drivers that contributes to the reduction of *Limnothrissa miodon*, effects of the reduction of *Limnothrissa miodon* on fishers, and marketeers, and strategies that can be used to sustain *Limnothrissa miodon* (Syabwanta, 2019). Three groups of eight to fifteen respondents were asked to seat in a conducive environment for discussions for the researcher to gather more information. The researcher contolled the proceedings of the discussions as a moderator.

4.6.1.3 Direct Observation

Direct observations (Appendix 11) were used to collect data from fishers, marketeers, and key informants as the researcher was conducting snowball sampling in the fishing villages along the lake. Some monofilament nets as well as mosquito nets as wrong fishing gears were seen. These observed nets are a contributing factor to the decline of Kapenta as these collects eggs, and fingerlings that are supposed to grow and increase.

4.7 Data Validation Methods

Validation is for internal consistency, for instance, for a logical problem whereas verification deals with the justification of knowledge assertions (Pedersen et al., 2000). The validity of a questionnaire (Appendix 4, 5, and 6) was determined by knowing what the researcher proposed to find out. Validity elucidated how well the collected data covered the actual area of research (Architha and Sreeramana, 2020). Additionally, validation was used to decide the rationality of extrapolation, and conclusions made, and founded on the results of the questionnaire (Architha and Sreeramana, 2020). Therefore, questions in the questionnaire where linguistically and analytically checked to find out what was supposed to be accessed founded on the respondent's understanding of the questions in the questionnaire (Appendix 4) (Architha and Sreeramana, 2020). The supervisor objectively evaluated the operations of constructs used in the questionnaire (Appendix 4), the prepared questionnaire format was ok, and the presentation of items in them was good, and recognized as a well-formulated instrument (Architha and Sreeramana, 2020). Items outlined in the questionnaire were realistic, perfect, and unambiguous for easy understanding (Architha and Sreeramana, 2020). Contents of items in the questionnaire

where checked to see whether they epitomized the whole theoretical concept of the intended model of the problem under contemplation (Architha and Sreeramana, 2020).

4.8 Analytical Framework

The analytical framework provided the basic terminology of ideas, norms, and terms that was utilized to construct types of causal description anticipated in philosophy (Coral and Bokelmann, 2017). Moreover, framework-based methods was practical as a way of dealing with intricacies that ascended in conditions connecting human relations with the environment (Coral and Bokelmann, 2017). This section presented an illustration of an application of "Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon*" to display part of the chosen analytical framework in the design of systemic research as it is considered, and as it progresses over a period of time (Coral and Bokelmann, 2017). This analytical framework aided, and organized the research by connecting theoretical questions to the realistic analysis while; serving as a stage for the construction of theoretical description that epitomizes the flow of information in numerous settings, and situations (Coral and Bokelmann, 2017). Figure 4.8 illustrates the analytical framework of this study that engaged how the data was analyzed.

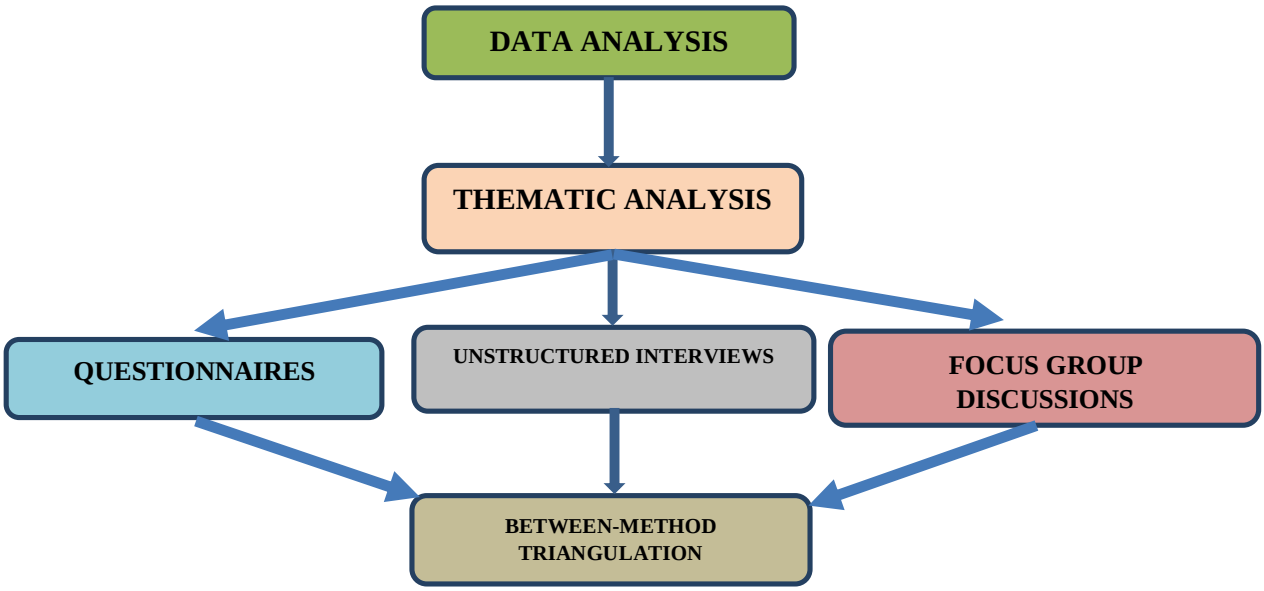

Figure 4.8: Analytical Framework on Effects of Decline of Kapenta in Mpulungu District
Source *:* Syabwanta, 2019

4.9 Limitations of the Study

This research work could not be concluded without a set of difficulties. Therefore, the constraints faced during this study were as follows;

Some respondents were not willing, and ready to express themselves on the subject of the study because they thought the researcher would go back to the district with punitive measures after some time to enforce the law on illegal fishing gear, and wrong fishing methods. Some respondents could not say things as they are, because they thought that what they would say would later turn against them. Additionally, participants were saying *Limnothrissa miodon* is God-given, and that it is not declining as they thought the researcher would incite policy makers after some time to institute punitive measures, and eventually ban them from fishing on the lake if they said *Limnothrissa miodon* on Lake Tanganyika is declining. Continuous probing was done to offset the above-mentioned constraints, and respondents were confidently advised that the data collected was purely for academic purposes only. Moreover, respondents asked for financial incentives after interviews but they were kindly informed by the research assistant in their language that they would not be given funds for interviewing them because they were visited, and interviewed from their respective fishing villages. Psychologically, the research assistant told them that they could have been given money if they were interviewed by the fisheries offices. Lastly, there were interruptions during interviews by children who were breast feeding when interviewing mothers, the researcher had to be patient, and conducted interviews successfully despite these interruptions.

4.10 Delimitations of the Study

The study of socio-ecological drivers, and dynamics of *Limnothrissa miodon* is not generalized to other areas but was pertinent to Lake Tanganyika of Mpulungu District of the Northern Province of Zambia. This then means that the data collected was only relevant to this region since *Limnothrissa miodon* is endemic to Lake Tanganyika. It could have been essential to cover the whole fishing villages surrounding Lake Tanganyika but because of inadequate time and insufficient resources, it was conducted in a few fishing villages among chosen fishers, marketeers, and key informants on the southern part of the lake. Therefore, the study targeted

one hundred, and twenty-four (124) respondents but it would have been vital to cover all fishing villages, thus, the research cannot be generalized.

4.11 Ethical Considerations

Philosophy deals with the behaviour of people, and guides morals, and values of conduct of individuals in interaction with each other (Akaranga and Makau, 2016). Therefore, ethics which are beliefs, lifestyles, and the societal principle of behaviour are differentiated between suitable, and improper behaviour (Akaranga and Maka, 2016). Various cultures have permitted rules that dictate manners but proper values are wider than laws. Nevertheless, citizens apply laws to implement ethical values (Akaranga and Maka, 2016).

In this study, possible harm (Appendix 10) to respondents was circumvented as every data gathered was done with the respondent's consent (Appendix 7). During interviews (Appendix 7) and Focus Group Discussions (FDGs) (Appendix 7), no uncomfortable and irrelevant questions (Appendix 7, and 10) were asked that caused embarrassment to respondents. Ethnic norms were upheld (Appendix 1, appendix 8, and appendix 9). Confidentiality (Appendix 7, and appendix 10) was assured to all respondents as names were not disclosed to anyone. The respondents were informed that the data collected was purely for academic purposes (Appendix 9) only.

CHAPTER FIVE

PRESENTATION OF FINDINGS

5.1 Introduction

The chapter elaborated graphical, and pictorial presentations of findings, and research questions from the General Respondents Questionnaire (Appendix 4) is the guide on headings of this chapter. Data collected from the field was presented using tables. Clarity, and simplicity in the presentation of findings of quantitative data were necessary for this chapter as the researcher used figures. Flow, and organization of data were followed. Additionally, this chapter captured the presentation of findings in an efficient approach, and the presentation focused on identifying trends that are in line with research objectives. Chronologically, recognized trends helped the researcher to examine Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* on Lake Tanganyika of Mpulungu District. This chapter presented findings to address the effects of the reduction of *Limnothrissa miodon* on fishers, and marketeers, and to suggest strategies that can be used to enhance the sustainability of *Limnothrissa miodon*. Findings are presented according to research questions as follows;

i. what factors contribute to the reduction of *Limnothrissa miodon?*
ii. what are the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers?
iii. what are the strategies that could be used to sustain *Limnothrissa miodon?*

5.2 Demographic Characteristics of Respondents

Respondents were asked questions seeking to know their Age, Gender, and Education in the study area. This helped the researcher to bring together the target population's profile.

5.2.1 Gender of Respondents

The gender of Respondents was important for understanding drivers contributing to the reduction of *Limnothrissa miodon* and the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers. It was also important to have diverse information on how fishers, and marketeers adapt to the effects of not sustaining *Limnothrissa miodon,* and how appropriate strategies could be used to increase their adaptive capacity. Presented in figure 5.2.1 is the gender of respondents.

Table 5.2.1: Gender of Respondents

Sex of Respondents	Respondents	Percentage
Male Fishers	87	70.1
Female Fishers	5	4
Male Marketeers	7	5.6
Female Marketeers	17	13.7
Male Key Informants	8	6.4
Female Key Informants	0	0
Total	**124**	**100**

Source: Field Data - May 2021.

The Gender of Respondents in table 5.2.1 shows male fishers, and female marketeers that were the majority. Results show that eighty seven (87) respondents representing seventy point-one (70.1%) per cent were male fishers; five (5) respondents representing four (4%) per cent were female fishers; seven (7) respondents representing five point six (5.6%) per cent were male marketeers; seventeen (17) respondents representing thirteen point seven (13.7%) per cent were female marketeers; eight (8) respondents representing six point four (6.4%) per cent were male key informants while; there were no female key informants.

5.2.2 Age of Respondents

The age of Respondents was important for understanding drivers that contribute to thereduction of *Limnothrissa miodon,* and the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers. This was important as it helped the researcher to bring together the target population's profile and saw how fishers, and marketeers adapt to the effects of not sustaining *Limnothrissa miodon,* and how appropriate strategies could be used to increase the adaptive capacity. Table 5.2.2 shows the results.

Table 5.2.2: Age of Respondents

Age of Respondents	Respondents	Per centage
21 – 35	48	39
36 – 50	66	53
51 – 65	7	6
66 +	3	2
Total	**124**	**100**

Source: Field Data - May 2021.

The age of the Respondents is presented in table 5.2.2. Forty-eight (48) respondents representing thirty-nine per cent (39%) were aged between twenty-one (21), and thirty-five (35) years; sixty-six (66) respondents representing fifty-three per cent (53%) were aged between thirty-six (36), and fifty (50) years; seven (7) respondents representing six per cent (6%) were aged between fifty-one (51), and sixty-five (65) years while; three (3) respondents representing two per cent (2%) were above sixty-six (66) years.

5.2.3 Number of Years of Respondents in School

The number of years of Respondents in school happens to be a yardstick measure on the reduction of *Limnothrissa miodon* and to some extent may present a benchmark on strategies to sustain *Limnothrissa miodon*. Table 5.2.3 shows the number of years a respondent has been in school.

Table 5.2.3: Number of Years of Respondents in School

Education	Respondents	Per centage
None	41	33
Primary	71	57
Secondary	7	6
Tertiary	5	4
Total	**124**	**100**

Source: Field Data - May 2021.

The number of years of Respondents in school shows that the majority had gone to school. Table 5.2.3 shows that forty-one (41) respondents representing thirty-three per cent (33%) did not attend school; seventy-one (71) respondents representing fifty-seven per cent (57%) attended

primary school; seven (7) respondents representing six per cent (6%) attended primary school and five (5) respondents representing four per cent (4%) attended tertiary education.

5.3 Causes of Decline of *Limnothrissa miodon*

According to the main objective of the research, the researcher examined Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon.* As part of the research question, fishers, and marketeers as well as key informants were presented with this question, what causes the decline of *Limnothrissa miodon*? Presented are findings in table 5.3.

Table 5.3: Causes of the Decline of *Limnothrissa miodon*

Causes of Decline of *Limnothrissa miodon*	**Respondents**	**Per centage**
Illegal Fishing Gear/Wrong fishing Methods	57	46
Rapid Population Growth	19	15
Advanced Fishing Technologies	5	4
Political Interference	1	0.8
Harvesting Kapenta in Breeding Areas	18	15
Nature of The Lake	1	0.8
Reduced Extension and Patrols	1	0.8
God's Will	4	3
Lack of Manpower	18	15
Total	**124**	**100**

Source: Field Data - May 2021.

Table 5.3 indicates causes of the decline of *Limnothrissa miodon,* and results show that fifty seven (57) respondents representing forty six per cent (46%) said illegal fishing gear, and wrong fishing methods caused the decline of *Limnothrissa miodon;* nineteen (19) respondents representing fifteen per cent (15%) said rapid population growth caused the decline of *Limnothrissa miodon;* five (5) respondents representing four per cent (4%) said advanced fishing technologies caused the decline of *Limnothrissa miodon;* one (1) respondent representing zero point eight per cent (0.8%) said political interference caused the decline of *Limnothrissa miodon;* eighteen (18) respondents representing fifteen per cent (15%) said harvesting fish in breeding

areas caused the decline of *Limnothrissa miodon;* one (1) respondent representing zero point eight per cent (0.8%) said the nature of the lake caused the decline of fish; one (1) respondent representing zero point eight (0.8%) said reduced policies, and patrols caused the decline of *Limnothrissa miodon;* four (4) respondents representing three per cent (3%) said the reduction of *Limnothrissa miodon* was by God's will and eighteen (18) respondents representing fifteen per cent (15%) said lack of manpower in the Department of Fisheries caused the decline of *Limnothrissa miodon.*

The section was also conducted through interviews. Questionnaires had a section of open-ended questions regarding Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon*. Participants during interviews in the study area were asked, what drivers contribute to the reduction of *Limnothrissa miodon*?

Key informant 1 had this to say;

> *Kapenta is declining because of the use of wrong fishing methods and illegal fishing gears that harvest eggs and small fish on the lake. Wrong fishing methods and illegal fishing gears used are Kutumpula and mosquito nets.*

Key informant 2 had this to say;

> *The district does not have adequate land and marine transport for their daily law enforcement operations on the lake and in fishing villages. This leads to inadequate patrols and monitoring by fisheries staff. With this lack of adequate transport, there is always an increase in fishing pressure as fishers harvest fish at will, at any time and they become heavily mischievous in their fishing activities. There is always demand for the resource and traders accept any size of fish caught from the lake. This motivates fishers to use undersized fishing mesh sizes as they are assured of a ready market at the end of each business day.*

It was also revealed Wrong fishing methods and illegal fishing gear are the cause of the decline of *Limnothrissa miodon* on the lake as some technologies used, and methods practiced are advanced. These technologies have a very bright light that highly attracts *Limnothrissa miodon* and collects everything including organisms as tiny as phytoplanktons. It was further said;

Limnothrissa miodon is declining because of rapid population growth. The lake is surrounded by several people and these people desire *Limnothrissa miodon* for household consumption and business as it is exported to other cities. Kapenta fishing on the lake is the only livelihood in Mpulungu District and there are many people on the bank of the lake that have since set-up fishing villages. On the other hand, other fishing villages that were sparsely populated in the recent past are now densely populated. Additionally, it was observed, fishers use nets of small mesh sizes that are less than four (4) and six (6) inches for harvesting breams and less than eight (8) and ten millimetres (10mm) for harvesting *Limnothrissa miodon* that are illegal. With this practice, small mesh-sized nets collect juvenile *Limnothrissa miodon,* and breams that are supposed to be recruited in the water body for breeding. Furthermore, the study also revealed; fishers harvest *Limnothrissa miodon* in breeding areas. *Limnothrissa miodon* breed in the shallow waters of the lake, and because of this, fishers seine in these areas on purpose. Further, fishers harvest *Limnothrissa miodon* in breeding areas on purpose. They target *Limnothrissa miodon* as it comes to breed in shallow waters. This has a disadvantage as the fish caught which is supposed to reach the grow-out stage, and breed is caught, and sold out in markets leading to the decline in catches of *Limnothrissa miodon.*

The study revealed the overabundance of fishers as the cause of the decline of Kapenta. The overabundance of fishers that come as far as DRC, Burundi, and Tanzania have introduced numerous advanced fishing gear, and wrong methods of harvesting *Limnothrissa miodon,* and therefore, *Limnothrissa miodon* cannot be spared. The study further revealed; Kapenta is declining because the Department of Fisheries does not have adequate manpower to carry out its law enforcement activities successfully. The department is under-capacitated to do with staffing levels, and this contributes to the decline of *Limnothrissa miodon*.

The section was also conducted through interviews with stakeholders. Questionnaires had a section of open-ended questions regarding the causes of the decline of *Limnothrissa miodon*. Stakeholders during interviews were asked, what causes the decline of *Limnothrissa miodon*.

The researcher intended to know the causes of the decline of *Limnothrissa miodon* in more detail and discussions in small meetings of about nine to twelve respondents were conducted. In this regard, a Focus Group Discussion was conducted in a more conducive environment to gather data from respondents with diverse views. As part of the research question, fishers, marketeers,

and key informants were presented with the question, and were asked to explain the causes of the decline of *Limnothrissa miodon*.

Figure 5.3: Focus Group Discussion Musende Fishing Village
Source : Field Data - 2021

Figure 5.3 indicates the Focus Group Discussions in Musende Fishing Village where fishers spoke about the causes and decline of *Limnothrissa miodon* on Lake Tanganyika

Key Informant N had this to say;

> *The study revealed that Kapenta is declining because of compromised law enforcement by the Department of Fisheries. Fisheries staffs are corrupt in their operations during extension, and research, and there is a cartel among officers within the Department of Fisheries in the district that are corrupt in their law enforcement operations.*

The findings of the study were that a selected few fisheries staff are indulging in corrupt activities regarding the conservation of *Limnothrissa miodon* by allowing fishers to use wrong fishing methods, and illegal fishing gear. When the fisheries team plan to undertake law enforcement operations and confiscate illegal fishing nets, and curb wrong fishing methods, a few dishonesty, unethical, and unprofessional fisheries staff perceived to be corrupt elites

privately/secretly tip off a selected few fishers to suspend fishing activities during the period the Department of Fisheries is conducting monitoring activities on the lake. In this case, these perceived corrupt elites in the district receive proceeds from fisher folks to harbour fisher's illegal fishing activities. When a few focused, and committed fisheries officers later monitor the lake, they find the right mesh-sized fishing nets. With these corrupt practices exhibited by few selected fisheries staff and a lack of staying true to law enforcement operations, catches of *Limnothrissa miodon* keep going down.

The study also revealed political interference in the dispensation of law enforcement operations in conserving *Limnothrissa miodon*. Department of Fisheries mandated with the responsibility of conserving the resource on the lake is prevented by the interference of politicians in their day-to-day law enforcement activities. When fisheries staffs, and police officers collect illegal fishing gear, and apprehend those involved in wrong fishing methods, and illegal fishing gears, politicians in the area tend to intervene, and let lose these erring offenders.

The study further revealed; there are more fishers on the lake than in the past few years, and these fishers have developed sophisticated wrong fishing methods as well as advanced illegal fishing gears. These advanced illegal fishing gears and wrong fishing methods of collecting *Limnothrissa miodon* are harmful compared to those used some years ago. With this, *Limnothrissa miodon* is easily and quickly harvested on the water body. The study also discovered that catches of *Limnothrissa miodon* on the lake are going down because of lack of the lake's biological rest. Other water bodies in the country have an annual fishing ban, and Lake Tanganyika has nothing. The lake does not rest from the fishing pressure it experiences each year.

Moreover, the study revealed; the Department of Fisheries in the district does not have adequate resources to conduct law enforcement operations on the lake. With reduced extension services and patrols, fishers become reckless, and mischievous activities are seriously witnessed due to inadequate monitoring by the Department of Fisheries. Fisheries staffs are unable to control illegal fishing gears and wrong fishing methods due to insufficient vehicles, outboard motor engines (boats), and/or motorbikes (transport) that are either in a deplorable state, borrowed from

other departments, left behind by projects or, packed for a long time in mechanical shops awaiting repair works.

5.4 Drivers that Contribute to Decline of *Limnothrissa miodon*

Several drivers influence the decline of fish globally and pertinently, some of these drivers contribute to the reduction of *Limnothrissa miodon* locally. A closed-ended question on the questionnaire was presented to fishers, marketeers, and key informants so they would provide the answers. Drivers that contribute to the decline of *Limnothrissa miodon* are presented in table 5.4.

Table 5.4: Drivers of Decline of *Limnothrissa miodon*

Drivers	**Respondents**	**Per centage**
The population of Fishers/Marketeers	27	22
Indiscriminate Fishing	92	74
Climate Change	5	4
Total	**124**	**100**

Source: Field Data - May 2021.

Results in Table 5.4 show that twenty-seven (27) respondents representing twenty-two per cent (22%) said the increased population of fishers, and marketeers contributed to the reduction of *Limnothrissa miodon;* ninety-two (92) respondents representing seventy-four per cent (74%) said indiscriminate fishing contributed to the reduction of *Limnothrissa miodon* and five (5) respondents representing four per cent (4%) said climate change contributed to the reduction of *Limnothrissa miodon.*

5.5 Effects of not Sustaining *Limnothrissa miodon*

Kapenta fishing is a source of food, employment and/or business for fishers and marketeers, and its sustainability is hampered by several challenges that leads to several effects. Additionally, people's lives are affected with this decline of Kapenta on Lake Tanganyika. The effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers are numerous within and beyond Mpulungu District. Table 5.5 indicates various effects of not sustaining *Limnothrissa miodon* as mentioned by key informants, fishers, and marketeers. The effects mentioned are presented in table 5.5.

Table 5.5: Effects of not Sustaining Kapenta

Effects	**Respondents**	**Per centage**
Hunger/Poverty	47	38
Loss of Livelihood	39	31
Loss of Funds	17	14
Standards of Living	11	9
Thievery Activities	10	8
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.5 shows the effects of not sustaining *Limnothrissa miodon.* Forty-seven (47) respondents representing thirty-eight per cent (38%) said hunger/poverty affected them due to declined levels of *Limnothrissa miodon;* thirty-nine (39) respondents representing thirty-one per cent (31%) said there was a loss of livelihood due to the decline of *Limnothrissa miodon;* seventeen (17) respondents representing fourteen per cent (14%) said there was a loss of funds due to the decline of *Limnothrissa miodon;* eleven (11) respondents representing nine per cent (9%) said standards of living were affected due to the decline of *Limnothrissa miodon;* ten (10) respondents representing eight per cent (8%) said there were too many thievery activities taking place in the area due to the declined levels of *Limnothrissa miodon.*

The section was also conducted through interviews. Questionnaires had a section of open-ended questions regarding the effects of not sustaining *Limnothrissa miodon* on fishers, and marketeers. Participants during interviews in the study area were asked how they were effected if *Limnothrissa miodon* is not sustained

A stakeholder Z had this to say;

> *Numerous people in the district rely on* Limnothrissa miodon *for consumption and its decline has caused many to wallow in hunger. Poverty levels in the district have increased as most people in the area and the country as a whole live below the poverty datum line (one dollar per day) and this unfortunate situation has increased the already existing poverty level.*

Stakeholder X had this to say,

> *People living along the lake do not engage in other livelihoods, for instance, agriculture as the lake shore is hilly and rocky making agriculture less practical. The decline of this precious resource has affected many lives that depend on fishing for survival. As levels of* Limnothrissa miodon *go down, people do not have funds to buy food and other necessities such as clothes and shoes. Kapenta fishing is an essential livelihood in the area and with this reduction in catches, people tend to venture into other livelihoods such as charcoal production that exacerbates the effects of climate change.*

The study revealed that the decline of *Limnothrissa miodon* leads to various challenges in communities one of which is hunger.

However, the researcher intended to know the effects of the decline of *Limnothrissa miodon* in more detail, and discussions in small meetings of about nine (9) to twelve (12) respondents were conducted. In this regard, a focus group discussion was conducted in a more conducive environment to gather data from respondents with diverse views on the topic of discussion. As part of the research open-ended question, fishers, marketeers, and key informants were presented with the question, and were asked to explain the effects of the reduction of *Limnothrissa miodon*.

The study revealed; the decline of *Limnothrissa miodon* prevents local people from taking their children to school. Parents that have school-going children rely on fishing to take their children to school and this reduction in catches of *Limnothrissa miodon* has forced many to stop taking their children to school. The decline of *Limnothrissa miodon* has brought forth compromised standards of living in the district. There is no money in circulation as this source of income is affected. The economic system in the district is destabilized as there are rampant and mischievous activities taking place. People settle for stealing and prostitution in a bid to find the money for survival.

The study also revealed; reduced catches on the lake leads to a scarcity of resources for local people at the household level. Kapenta fishing is the only livelihood in the district; its decline has led to numerous criminal activities. Starvation has increased due to the decline of *Limnothrissa*

miodon and thievery activities are on the rise as Kapenta sales/catches have gone down. Life has become unbearable for many in the district as *Limnothrissa miodon* catches have kept on reducing. During interviews, selected respondents mentioned that the practice of wrong fishing methods and the use of illegal fishing gears are rampant. Admittedly, the decline of fish and precisely *Limnothrissa miodon* is due to wrong fishing methods and illegal fishing gear. The majority of these fishing gears are unauthorized mesh sizes. In the process of looking for respondents to interview along the bank of the lake, these fishing gears were abundantly observed. In this regard, common illegal fishing gears mentioned by selected participants and observed include mosquito nets and monofilament nets that were of smaller mesh size. It was then revealed; fisheries staffs try to enforce the law on illegal fishing gears and wrong fishing methods despite the challenges of inadequate manpower and resources. This, therefore, affects the sustainability of *Limnothrissa miodon.*

Figure 5.5 : Mosquito Nets
Source : Field Data - 2021

A fisher mentioned that these are illegal fishing gear commonly used for fishing breams and harvesting Kapenta. Monofilament fishing nets left or, lost in the lake by fishermen entangle fish. The monofilament nets restrict the movement of fish that it has caught causing starvation, lacerations and infection in these living organisms that need air and food. Mosquito nets collect eggs and harvest juvenile *Limnothrissa miodon* that are supposed to be added to the fisheries. Fishers harvest *Limnothrissa miodon* in breeding areas. It is difficult for *Limnothrissa miodon* to propagate as most fishing activities take place in breeding areas. Fishers harvesting Kapenta in

breeding areas on purpose exacerbate its decline. The FGD comprised ten selected fishers, one former fisheries staff and the researcher. During the focus group discussion, fishers lamented over inadequate manpower in the Department of Fisheries.

5.6 Strategies to Sustain Kapenta

This section of the study was meant to find out strategies that could be used to sustain *Limnothrissa miodon*. Interviews were carried out using an open-ended questions to ascertain strategies that could be used to sustain *Limnothrissa miodon*. Fishers, marketeers, and key discussants were asked the question well formulated from questionnaires. Table 5.6 indicates results obtained from respondents on strategies that could be used to sustain *Limnothrissa miodon*. Findings are presented in table 5.6.

Table 5.6: Strategies to Sustain *Limnothrissa miodon*

Measures	**Respondents**	**Per centage**
Law Enforcement	44	35
Annual Fish Ban	31	25
Freshwater Protected Areas	5	4
Alternative Livelihoods	17	14
Adequate Transport	11	9
Reduced Political Interference	7	6
Maintain Hard Working Staff	9	7
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.6 indicates strategies that can be used to sustain *Limnothrissa miodon*. Results show that forty four (44) respondents representing thirty five per cent (35%) preferred law enforcement by the Department of Fisheries with other agencies to sustain *Limnothrissa miodon;* thirty one (31) respondents representing twenty five per cent (25%) needed introduction of annual fishing ban on the lake to sustain *Limnothrissa miodon;* five (5) respondents representing four per cent (4%) said they needed freshwater protected areas to sustain *Limnothrissa miodon;* seventeen (17) respondents representing fourteen per cent (14%) said they needed alternative livelihoods to sustain *Limnothrissa miodon;* eleven (11) respondents representing nine per cent (9%) asked for adequate transport for fisheries staff for operations to sustain *Limnothrissa miodon;* seven (7) respondents representing six per cent (6%) said they needed reduced political interference on

affairs of the lake to sustain *Limnothrissa miodon* and nine (9) respondents representing seven per cent (7%) said they needed hard working staff in law enforcement operations to be maintained and/or retained within the district so Kapenta can be sustained.

The section was also conducted through interviews. Questionnaires had a section of open-ended questions regarding measures that could be used to sustain *Limnothrissa miodon*. Participants during interviews in the study area were asked, what measures could be used to sustain *Limnothrissa miodon*.

Key Informant K had this to say;

> *Frequent law enforcement operations on the use of wrong fishing methods and illegal fishing gears on the water body are needed. Precisely, mosquito nets must be confiscated by the Department of Fisheries from time to time. And there is also a need to reduce the number of boats on the lake.*

Key informant M had this to say;

> *Biological rest on the lake is needed like what happens to other water bodies in the country. Harvesting of fish year in and year out on the lake leads to the decline of* Limnothrissa miodon*. The Department of Fisheries should merge with other riparian states to try and introduce an annual fishing ban on the lake for some months so that fish can propagate.*

The study revealed the need for sensitization on wrong fishing methods and illegal fishing gears such as mosquito nets that collects eggs, and harvest juvenile *Limnothrissa miodon*. It must be emphasized then that these mosquito nets received from clinics, and hospitals are given to people as treated bed nets with the view to protect them from mosquito bites to prevent malaria, and must be used as designed by the Ministry of Health, and should be utilized as such. Fishing methods like Kutumpula must be discouraged at all costs, and fishers should be stopped from practicing this fishing method as it disturbs the breeding process of fish on the lake. The study also discovered the need to maintain hard-working staff in the district including police officers as

the previously transferred police officers stayed true to law enforcement operations as they monitored net mesh sizes, fishing gears, and wrong fishing methods on the lake.

The researcher intended to know the strategies that can be used to enhance the sustainability of *Limnothrissa miodon* in more detail, and discussions in small meetings of about nine (9) to twelve (12) respondents were conducted. In this regard, a focus group discussion was conducted in a more conducive environment to collect data from respondents with diverse views. As part of the research question, fishers, marketeers, and key informants were presented with the question and were asked to explain strategies that can be used to avert the causes of the reduction of *Limnothrissa miodon*.

Figure 5.6: Focus Group Discussion in Kasasa Fishing Village
Source : Field Data – 2021

Figure 5.6 shows fishers and marketeers in a focus group discussion in Kasasa Fishing Village of stratum two of Lake Tanganyika.

Stakeholder P had this to say;

> *Make and/or strengthen Village Conservation and Development Committees to see to it that Limnothrissa miodon is protected from ruthless methods of harvesting. Extension services by the Department of Fisheries should be strengthened in regulating mesh sizes used in fishing.*

The Focus Group Discussion revealed the increasing the number of breeding areas on the lake is needed. The current breeding areas should be monitored and patrolled frequently by the

Department of Fisheries from time to time to stop people from fishing in these restricted areas. There is a need to enforce the law on the use of small mesh-sized nets when harvesting *Limnothrissa miodon.* The study revealed the need to encourage and/or empower fishers and marketeers through loans for them to diversify in other livelihoods. Suggested alternative livelihoods by respondents include fish farming through fish cages on the lake and small livestock production. Others asked for regular meetings to be conducted by the Department of Fisheries with fishers, and marketeers to sensitize them on the use of the right mesh-sized nets when fishing, and law enforcement activities. It was echoed then that emphasis be made in these meetings on the importance of conserving *Limnothrissa miodon* as this is done in their interest.

The study also revealed the need for adequate marine, and land transport for the Department of Fisheries for smooth law enforcement operations. Motor vehicles, bikes, boats, and outboard motor engines should be repaired from time to time so the Department of Fisheries carries out its mandate of conserving the resource. The Department of Fisheries needs to monitor the lake, and frequently control the size of *Limnothrissa miodon* that is harvested. The study also re-sounded the need to use the right mesh-sized nets when fishing on the lake which are four (4) and six (6) inches for fishing Oreochromis species and eight (8), and ten millimetres (10mm) for harvesting *Limnothrissa miodon*. The study further revealed the need for frequent extension, and research by fisheries staff on mindset change, and encouraging fishers, and marketeers to venture into alternative livelihoods as fishing must not be viewed as an only livelihood. To conserve *Limnothrissa miodon*, there is a need for fishers, and marketeers to venture in other livelihoods such as agriculture, and small livestock production.

Participants pleaded; there must be no interference from politicians in the conservation of the Tanganyika sardine, and powers-that-be must humbly relinquish their powers to responsible people to do their work. Politicians must be meekly asked to stop intimidating staff in the Department of Fisheries as they carry out their duty in enforcing the law on the conservation of *Limnothrissa miodon*. Locals must also be politely educated not to be influenced by powers-that-be, and must not be used by powers-that-be on affairs of the lake because it's these same locals whose livelihood will be affected if *Limnothrissa miodon* catches keeps going down.

5.7 Extension and Research

Extension and research play a critical role in sustaining Kapenta as well as sensitizing fishers, and marketeers on the importance of conserving *Limnothrissa miodon.* Table 5.7 indicates whether extension, and research are done in the study area.

Table 5.7: Extension and Research

Extension/Research	Respondents	Per centage
Yes	75	60
No	49	40
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.7 indicates seventy-five (75) respondents representing sixty per cent (60%) said they received an extension worker from the Department of Fisheries, and that research was conducted on the lake, and forty-nine (49) respondents representing forty per cent (40%) said they did not receive an extension worker from government and that research was not done.

5.7.1 Frequency of Extension and Research

Frequent extension, and research are important for the conservation of fish in capture fisheries. Table 5.7.1 shows the frequency of extension, and research conducted by fisheries staff in the study area.

Table 5.7.1: Frequency of Extension and Research

Frequency	Respondents	Per centage
Monthly	11	9
After 3 Months	23	19
After 6 Months	17	14
Annually	73	58
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.7.1 shows eleven (11) respondents representing nine per cent (9%) said they were visited monthly; twenty-three (23) respondents representing nineteen per cent (19%) said they were visited after every three months; seventeen (17) respondents representing fourteen per cent

(14%) said they were visited after every six (6) months; seventy-three (73) respondents representing fifty-eight per cent (58%) said they were visited every after twelve months.

5.8 Types of Extension and Research

Types of extension, and research are important for the conservation of fish in capture fisheries. Table 5.8 shows types of extension, and research conducted by fisheries staff in the study area.

Table 5.8: Types of Extension and Research

Types	**Respondents**	**Per centage**
Law Enforcement	29	23
Licensing Boats	38	31
Catch Assessment Surveys	41	33
Monitoring of Breeding Areas	16	13
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.8 shows twenty-nine (29) respondents representing twenty-three per cent (23%) that indicated that the Department of Fisheries conducted law enforcement in the area; thirty-eight (38) respondents representing thirty-one per cent (31%) said the Department of Fisheries conducted boat licensing; forty-one (41) respondents representing thirty-three per cent (33%) said the Department of Fisheries conducted Catch Assessment Surveys and sixteen (16) respondents representing thirteen per cent (13%) said the Department of Fisheries monitored breeding areas on the lake.

5.9 Importance of Extension and Research

Conservation of fish attaches great importance to extension, and research in capture fisheries. Table 5.9 shows how vital extension, and research are in the study area.

Table 5.9: Importance of Extension and Research

Importance	Respondents	Per centage
Yes	121	98
No	3	2
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.9 indicates one hundred and twenty-one (121) respondents representing ninety-eight per cent (98%) who said that extension, and research were significant and can improve fish numbers on the lake while; three (3) respondents representing two per cent (2%) said that extension, and research were not that essential, and would not improve fish quantities on the lake.

5.10 Government Intervention

Government intervention in conserving fisheries resources play a critical role in protecting biological resources. Table 5.11 shows government intervention in promoting the sustainability of *Limnothrissa miodon* in the study area.

Table 5.10: Government Intervention

Government Intervention	Respondents	Per centage
No	119	96
Yes	5	4
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.10 indicates one hundred nineteen (119) respondents representing ninety-six per cent (96%) who said that there was no government intervention regarding the sustainability of *Limnothrissa miodon,* and five (5) respondents representing four per cent (4%) said that there was government involvement in sustaining *Limnothrissa miodon*.

5.11 Adequacy of Intervention

Adequate interventions by the government in conserving fish resources play a critical role in protecting biological resources. Table 5.11 shows the adequacy of government intervention in promoting the sustainability of *Limnothrissa miodon* in the study area.

Table 5.1: Adequacy of Interventions

Adequacy of Intervention	Respondents	Per centage
Yes	5	4
No	119	96
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.11 indicates one hundred nineteen (119) respondents representing ninety-six per cent (96%) said that government intervention regarding the sustainability of *Limnothrissa miodon* was inadequate, and five (5) respondents representing four per cent (4%) said that involvement by the government to sustain *Limnothrissa miodon* were sufficient.

5.12 Examples of Projects by Government

A open-ended question in the questionnaire was presented to respondents to mention examples of government intervention that promote the sustainability of *Limnothrissa miodon,* and its key discussants that had the best idea of specific government projects that are conducted to promote the sustainability of *Limnothrissa miodon.*

A key informant N had this to say;

> *Examples of government interventions in promoting the sustainability of* Limnothrissa miodon *are projects like the Lake Tanganyika Development Project (LTDP), the Food and Agriculture Organization (FAO), and The United Nations Development Programme/Global Environmental Facility (UNDP/GEF).*

The study revealed; Lake Tanganyika Development Project (LTDP) through cooperating partners is for the improvement of natural resources, and livelihoods of communities in Zambia's Lake Tanganyika Basin through the sustainable, and integrated use of the lake resource. It was further disclosed; The Lake Tanganyika Development Project (LTDP) was formulated within the framework of the Zambian Long-Term Vision known as Vision 2030 with which the country aimed at becoming "A Prosperous Middle Income Nation by 2030. It is an integrated project whose aim was to protect the ecological integrity of the Lake Tanganyika basin, and improve the quality of lives of the basin population through the provision of essential economic

infrastructure, and supporting the sustainable livelihood of the local people. The study further revealed; the Food and Agriculture Organization (FAO) initiative is a project that is in the pipeline, and will be looking at the conservation of small species of fish like *Limnothrissa miodon,* and *Stollothrissa tanganicae*. Additionally, the study revealed; The United Nations Development Programme/Global Environmental Facility (UNDP/GEF) Project is a partnership intervention for the implementation of the Strategic Action Programme for Lake Tanganyika whose aim was to address major environmental challenges in the lake basin including pollution, sedimentation, and habitat destruction.

5.13 Proposed Management Approaches to Sustain Kapenta

The questionnaire had a final closed-ended question in which respondents were asked to suggest management approaches that could be used to sustain Kapenta. The proposed strategies for government to sustain *Limnothrissa miodon* are central to conserving this biological resource. Table 5.13 shows strategies government can use to enhance the sustainability of *Limnothrissa miodon* in the study area.

Table 5.13: Proposed Strategies to Sustain Kapenta

Strategies by Government	**Respondents**	**Per centage**
Increase Marine Transport	2	1.6
Increase Extension Staff	42	33.8
Gear/Methods Regulations	79	63.7
Reduce the Number of Fishers	1	0.8
Total	**124**	**100**

Source: Field Data - May, 2021.

Table 5.13 indicates proposed strategies that can be used by the government to sustain *Limnothrissa miodon*. Results show that two (2) respondents representing one point six per cent (1.6%) preferred increased transport for the Department of Fisheries to sustain *Limnothrissa miodon*, forty-two (42) respondents representing thirty-four per cent (34%) needed increased extension by the Department of Fisheries to sustain *Limnothrissa miodon*, seventy-nine (79) respondents representing sixty-four per cent (64%) said they needed regulation of illegal fishing gears, and wrong fishing methods by the Department of Fisheries to sustain *Limnothrissa*

miodon, and one (1) respondent representing zero point eight per cent (0.8%) said they needed numbers of fishers to be reduced on the lake as an approach to sustain *Limnothrissa miodon*.

CHAPTER SIX

DISCUSSION OF FINDINGS

6.1 Introduction

This chapter presented both the general summary of research findings, and a synopsis of findings as per the research objective. The chapter further presented a discussion of findings as per the specific research objectives of the study.

6.2 Discussion of Findings

6.3.1 Causes of the Reduction of *Limnothrissa miodon*

According to findings, primary drivers that contribute to biomass reduction of *Limnothrissa miodon* are Gender, Age, and Education. These are vital for determining the extent of major drivers that contribute to the reduction of *Limnothrissa miodon*. These are intensified by key factors which include; wrong fishing methods and illegal fishing gears, rapid population growth, advanced fishing technologies, political interference, harvesting of *Limnothrissa miodon* in breeding areas, nature of Lake Tanganyika, reduced policies, and patrols, God's will, and lack of manpower.

6.4 Primary Drivers

6.4.1 Gender of Respondents

Donda and Njaya, 2007 agreed and said; women often play an important role in fisheries activities. Donda and Njaya, 2007 further said; auxiliary industries like boat building, and maintenance, boat engine servicing, and net manufacturing offer employment opportunities to people both in rural, and urban areas. On the contrary, WWF, 2012 disagreed and said; fishing is often seen as a male-dominated activity especially where this involves boats, equipment, and long absence at sea, though women play a key role in maintaining equipment, processing, and marketing of fish.

The results on gender of respondents is further supported by WWF, 2012 who said; women's role are often less acknowledged in/during fishing. Women are mainly involved in the marketing

of fishery products than processing or, active fishing. Cliffe and Akinrotimi, 2013 also agreed and said; women are more involved in picking up, for instance, shellfish such as oysters, and periwinkle at low tide than fishing in creeks, and rivers. FAO, 2015 also agreed and said; women can also be commended for the critical role they play in every link of the value chain in small-scale fisheries, although these best-known roles are in the processing, and marketing of fish, and other fisheries products.

6.4.2 Age of Respondents

Wales and Mvula, 2009 agreed and said; older fishers may have accumulated capital, more contacts with fellow fishers, better preferred by credit institutions, and larger family sizes all of which may make them more prepared to choose a particular fishing location than younger ones. Wales and Mvula, 2009 further said; age in the crew during fishing is a very important factor in the choice of fishing locations as it relates to the accumulated knowledge of fishing behaviour.

Moreover, Wales and Mvula, 2009 added; the positive sign indicates that with an increase in age, there is more propensity of fishers to go offshore which results in their willingness to try out new fishing grounds in offshore areas which are underexploited. Wales and Mvula, 2009 also added; it is reported then that an increase in age-induced salmon seiners in Alaska exploit offshore areas where they realized more catches. Shyam et al., 2013 concurred with Wales and Mvula, 2009 and said; thus, fisheries continue to be the livelihood of more than 82.5% of youths, and older people. Bako and Balla, 2010 also said; this implies then that the majority of fishermen are in their productive age, hence, it is expected of them to have high productivity. Carothers and Sepez, 2003 also added; with fewer crew jobs available, boat captains may be more selective in hiring likely favouring age, and experience. On the other hand, Frijlink and Lyle, 2010 alluded; youth engagement in fishing is also attributed to greater importance in catching fish.

6.4.3 Number of Years of Respondents in School

Vieira et al., 2013 agreed and said; probably, the early initiation of fishing activities in young people in traditional communities echoes in school life, hence, the low education level of young fishers. Vieira et al., 2013 further said; informal, and subjective evidence of people working with fishing communities suggests that they are prone to low levels of literacy, and schooling.

Maddox, 2007 conquered with Vieira et al., 2013 and said; it has been suggested then that a vicious cycle of illiteracy exists in fishing communities which is both a result and cause of continued poverty. Maddox, 2007 also said; the majority of fishers and marketeers are poor at a small-scale level. Maddox, 2007 further said; their poverty encompasses more than just income, it includes lack of land ownership, a high degree of indebtedness, poor access to health, education, and financial capital, and political, and geographical marginalization. WWF, 2012 concurred with Maddox 2007 and said; it is women who are often most vulnerable, and bear the brunt of these constraints, and challenges.

6.5 Causes of Decline of *Limnothrissa miodon*

Equally, the causes of the decline of *Limnothrissa miodon* are supported by other scholars, for instance, Standing, 2008 who said; Africa's marine resources are increasingly in demand, and are gaining in geo-political importance. Standing, 2008 mentioned; competition between key fishing villages for access, and control over marine resources is joined by competition between local communities, and industrialized foreign fishing fleets. Standing, 2008 further said; corruption in marine fisheries deals with both administrative corruption, and a more complex understanding derived from the notion of political corruption, and state capture. Standing, 2008 added; there is corruption, and there are potential negative impacts on democratic governance by fisheries access agreements. Standing, 2008 alluded; conflicts of interest, and embezzlement by public officials, and bribe payments, and other forms of corruption undermine efforts at policing illegal fishing.

Additionally, Lemaître, 2021 concurred with Standing, 2008 who said; fisheries agents who provide services for vessel owners are active in orchestrating corrupt practices across the region. Lemaître, 2021 also said, they link up with corrupt players offering them protection, and paying bribes, and arranging kickbacks. Lemaître, 2021 further said; fish that is caught illegally often facilitated by corruption is likely to be whitewashed into a legitimate value chain if illegal activities are not detected before the catch is transshipped or, landed. Lemaître, 2021 alluded; fisheries conflicts are increasing in both frequency, and intensity. Sarah et al., 2018 concurred with Lemaître, 2021 who said; the two primary causes of fisheries conflicts are illegal fishing, and the declining fisheries population. Ritzau et al., 2014 agreed and said; much marine fish

stocks is overexploited, and considerable overcapacity exists in fishing fleets worldwide. Ritzau et al., 2014 further said; conversely, one of the reasons for the imbalance between resource availability, and fishing capacity is technological development which continuously increases the efficiency of vessels, a mechanism referred to as “technological creep”.

Furthermore, Afoakwah et al., 2018 agreed, and said; light fishing is a type of fishing which uses light attached to a structure above water or, suspended underwater to attract fish, and fishers to go to specific areas to harvest them. Afoakwah et al., 2018 also said, just as fishermen seek conditions where chances of catching fish are optimized, fishes seek areas where chances of food are optimal. Afoakwah et al., 2018 further said; wrong, and illegal fishing gears involves the use of monofilament nets with mesh sizes less than seventy-five millimetres in stretched diagonal length in a river system or, marine waters as stated in the Fisheries Act. Afoakwah et al., 2018 alluded; capture fisheries, conversely, are undergoing various setbacks from anthropogenic activities, namely, population growth, habitat destruction, pollution, invasive species introduction; overfishing, and climate change. Bustamante et al., 2018 concurred with Afoakwah et al., 2018 who said; anthropogenic causes of the decline of fish include habitat conversion, for instance, degradation of land, and aquatic habitats, deforestation, afforestation, exploitation of wild population, climate change, water, and air pollution and species introduction.

Moreover, Hardin, 1968 agreed, and said; the increasing human population, escalating income, consumer demand, growing markets, and enhanced technologies all lead to the overharvesting of living organisms. Hardin, 1968 also said; individuals, communities or, corporations that have open, and unfettered access to community supplies like forests, aquifers, fisheries, and grazing land can spoil a shared resource to make the most out of short-term proceeds until it ultimately becomes unavailable for multitudes. Wana, 2016 concurred with Hardin, 1968 who said; the separate major reasons for the loss of fish are fishing methods, absence of policies governing fisheries management, for instance, fishers fishing in breeding areas, lack of regular management of resources from the side of government, poor extension, and research services, and disintegration of duty, and irresponsibility in diverse institutions.

6.6 Effects of not Sustaining *Limnothrissa miodon*

Therefore, the effects of not sustaining *Limnothrissa miodon* mentioned in the study area are supported by Coll et al., 2008 who said; unstable population growth exacerbates poverty in small coastal communities, and developing nations by increasing pressure on local resources. Coll et al., 2008 also said; ultimately, this negatively affects local economies because they overexploit already vulnerable, and top-predator fish stock resulting in issues of food scarcity and loss of livelihood in future. Jones 2013 also concurred with Coll et al., 2008 who added; fish are what are known as common-pool resources, as a result, poverty increases as they are overharvested. Jones, 2013 further said; although the developed world is most responsible for the unstable state of global fish stocks due to their insatiable appetite for top-predator fish, it is the world's poor people that will face the burden of these socio-economic, and ecological disasters. Jones, 2013 also said; the current situation creates local societal challenges such as unemployment, poverty, lack of good health, lack of educational opportunities, frustration, and societal tensions between the local population losing their traditional way of income generation, and livelihood. Jones, 2013 alluded; declining fisheries resources that have been a source of employment in numerous West African countries, for instance, force countless young people to migrate to large cities or, neighbouring countries where work is hard to find. Jönsson, 2019 concurred with Jones, 2013 who said; for example, families no longer have any resources, and income to afford their children's education, and healthcare, and are living under inhuman conditions which depends on foreign exploitation of these people, and area resources. Jönsson, 2019 added; this then leads to destructive consequences for people's livelihood, and forces some to get involved in mischievous activities in their struggle for survival; activities like crime or, simply leaving their traditional villages. Jönsson, 2019 also said; indeed, the economic system in society is affected if fish decline in waterbodies. Jönsson, 2019 alluded; declining fishing opportunities influence various aspects of the local community's sustainable lifestyle, and living conditions forcing several youths to migrate to urban centres in search of employment. Additionally, Jönsson, 2019 said; numerous young West Africans, for instance, end up as "illegal migrants" in other countries. Moreover, Jönsson, 2019 said; migration to Europe is for many a very costly, and dangerous process with major risks to migrant's lives. Jönsson, 2019 commented; the desperate endeavour of countless people to tackle poverty, and the destruction of their traditional life opportunities force them to move to urban areas in major West African cities, and Europe.

Daniels et al., 2016 concurred with Jönsson, 2019 who said; the exhaustion of fisheries resources can create overwhelming societal, monetary, and human consequences. Daniels et al., 2016 also said; the livelihood of artisanal fishers is destroyed by an unsustained fish species, and an essential basis of protein is also lost, and chances for expansion of regional production, and trade disappear.

6.7 Strategies to Sustain *Limnothrissa miodon*

Strategies explained by respondents in the study are supported by Tursi et al., 2015 who said; to reach GES, each member state surrounding Lake Tanganyika must develop a freshwater strategy which must be agreed upon with all neighbouring member states. Huang and He, 2019 said; the annual fishing ban and suspension of freshwater fishing activities must be fully adopted on the lake to save natural resources. Huang and He, 2019 also said; besides, restraining fishing gears, all freshwater fishing operations should from time to time be suspended say two to three months during the fishing ban period each year, and breeding sites should have various suspension policies. Huang and He, 2019 added; it can then be a vital direction of Zambia's coastal, and inland fisheries administration to bring in a Right-based Fishing System (RbFS). Huang and He, 2019 further said; this is because the worldwide group of people attach great importance to Right-based Fisheries Management (RbFM), and United Nations Food and Agriculture Organization (UNFAO) organises precise seminars concerning this subject annually. Huang and He, 2019 alluded; this could then be the beginning of the Right-based Fisheries System (RbFS) in Zambia that can inspire fishers, and fish traders to conserve fishing areas, and their resources. Njiru et al., 2017 also alluded; Government of the Republic of Zambia should change management strategies, and bring in stakeholders through community involvement on Lake Tanganyika by forming Beach Management Units (BMUs). Njiru et al., 2017 also said; this community involvement in the management of the Lake Tanganyika Fisheries will see a general improvement in fish catches. Daniel and Benjamin, 2001 also added; to meet the challenges of overfishing, a Precautionary Procedure, and Harvest Control Rule (PPHCR) management ideology should be introduced in major fisheries around the lake. Daniel and Benjamin, 2001 added; the Department of Fisheries should bring in a set of rules grounded on pre-defined significant standards which could be attuned as more information is gained. Winder, 2018 said; a more deep-seated option is to declare definite locations of the lake "no-go areas," and make

fishing in such locations rigorously unlawful so fish in such places can have time to improve, and repopulate. Winder, 2018 further said; aquaculture is yet another copying measure which involves the farming of fish in captivity. Winder, 2018 added; this element efficiently privatizes fisheries resources, and creates inducements for farmers to preserve their resources as it also reduces ecological impacts on the lake.

6.8 Theoretical Underpinnings

The uncertainty theory advanced the purpose of providing a clear understanding, and making sound decisions to contribute to national development. The theory is advanced in which fishers, marketeers, as well as fisheries staff would be involved in educating, and helping the public to address many societal issues existing within society, and the natural environment. These proposed strategies would empower marketeers, fishers as well as fisheries staff to engage in a more informed discourse which in turn can lead to better decision-making, and enhance the achievement of the *United National Sustainable Development Goals* such as Sustainable Development Goals number one (1), and two (2) which focuses on ending poverty, and hunger, and archiving food security by 2030. All countries across the globe are tasked to propose, develop, and plan strategies to address the facet of environmental problems starting from local to the international level. Uncertainty theory underpins the findings of the study that knowledge could be created through interaction, sharing of experiences, and observations among fishers, marketeers, fisheries staff, and the researcher. The theory also agreed with the findings that there is a need for the involvement of various stakeholders to sustain *Limnothrissa miodon* to address the problem. Fishers, and marketeers suggested the involvement of the Ministry of Fisheries, Ministry of Water Affairs, Ministry of Green Economy and Environment, Ministry of Agriculture, Civil Society Organizations, and other partners in promoting strategies to increase collaboration with the Village Conservation, and Development Committees (VCDC) in sustaining Kapenta. The summary of the application of the theory of uncertainty is indicated in Figure 6.8.

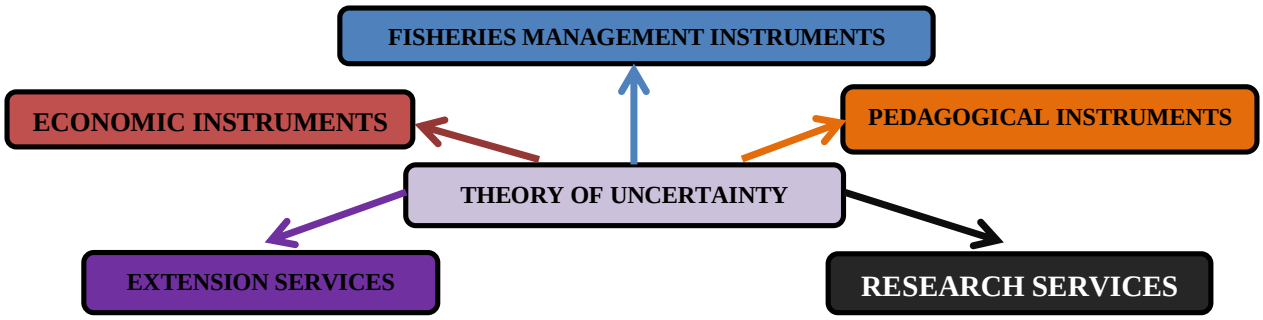

Figure 6.8: Application of the Theory of Uncertainty
Source : Field Data, 2021

Figure 6.8 show the theoretical underpinnings where marketeers, and fishers could be engaged through involvement in extension services to understand how fish breed, and getting engaged in knowledge acquisition through pedagogical instruments along the bank of Lake Tanganyika, thereby reducing the pressure, and fishing effort on the lake.

CHAPTER SEVEN

CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH AREAS

7.1 Introduction

This chapter contained conclusions, recommendations, and explained the position in relation to Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* on Lake Tanganyika of Mpulungu District of the Northern Province of Zambia. Explicitly, the research study pursued drivers of the reduction of Kapenta, effects of the decline of Kapenta on fishers, and marketeers, and strategies that could be used to sustain Kapenta. The case study targeted fishers, and traders as well as key informants. A qualitative method was used to capture the attitudes, views, ideas, and opinions of respondents on the reduction of Kapenta.

7.2 Conclusions

The main findings of the Socio-ecological Drivers, and Dynamics of *Limnothrissa miodon* on Lake Tanganyika attributed the decline of Kapenta to indiscriminate fishing, the increase of population of fishers, and marketeers, and climate change. There are a lot of fishers engaging in fishing activities on the lake. Additionally, the number of fishers, and marketeers on the lake increased in the recent past. On the other hand, climate change is impacting a variety of biotic elements that are firmly connected to the production, and distribution of fish species population, and these climate-driven biotic changes are probably different amid the open ocean, shelf seas, and coastal waters.

The study also concluded that the causes of the reduction of Kapenta is because of illegal fishing gears, and wrong fishing methods, rapid population growth, advanced fishing technologies, political interference, harvesting Kapenta in breeding areas, the nature of the lake, reduced extension, and patrols, God's will and lack of manpower. The use of illegal fishing gears, and wrong fishing methods have a contributing factor on the decline of Kapenta on this waterbody. The fishing gears are unselective when harvesting fish as they tend collect Kapenta that is supposed to be recruited in the waterbody for production. These gears have the capacity to seine fingerlings and eggs affecting the abundance of aquatic resources on Lake Tanganyika. Wrong

methods of fishing are a disturbance in the lake when fishing as it disturbs the breeding of fish. The use of light as a fishing method on the other hand attracts fingerlings, and Kapenta that are supposed to be reproduced for the production. The more the fishers the lake accommodates in harvesting fish affects the abundance of this aquatic resource. Population growth around the lake and the district as a whole is contributing to the reduction of aquatic resources as the people around the lake are in dare need of Kapenta for consumption and for business. The bank of the lake was sparsely populated some decades ago but currently, there is an increase in the number of people in fishing villages, and markets, and this is a contributing factor on the status as well as abundance of *Limnothrissa miodon* on the lake. Moreover, fishers tend to harvest *Limnothrissa miodon* in breeding areas on purpose. Fishing in breeding areas is also an adverse issue on the abundance of Kapenta on the lake. Fishers target *Limnothrissa miodon* as it comes to breed in shallow waters. On the other hand, the use of fishing equipments with bright light attracts all types and sizes of *Limnothrissa miodon* and collects everything including organisms as tiny as phytoplanktons, therefore, this is affecting the abundance of Kapenta on the lake.

7.3 Recommendations

To ensure that socio-ecological drivers are reduced or, even eliminated, the following recommendations;

i. The study revealed that fishers practice wrong fishing methods and use illegal fishing gear, therefore, there is a need to employ more fisheries staff in the Department of Fisheries to control the use of illegal fishing gear, and curb the practice of wrong fishing methods.
ii. The study revealed that there is an interference of politicians on operations of the lake, therefore, those involved in politics around the lake to stop intimidating staff in the Department of Fisheries within the district so they carry out their duties pretty well in enforcing the law on the conservation of *Limnothrissa miodon*.
iii. The study revealed that there is the growth of population as seen from the increased fishing villages on the bank of the lake, therefore, the Department of Fisheries should heighten extension and research along the bank of Lake Tanganyika and other parts of the water body so fishers are engaged in the correct way of harvesting Kapenta.

iv. The study revealed that fishers harvest fish in breeding areas on the lake, therefore, there is a need to educate fishers that *Limnothrissa miodon* is a common-pool resource so fishers and/or marketeers can harvest and/or trade this resource with caution.

v. The study revealed that there is inadequate marine and land transport at the district level for the Department of Fisheries to adequately expedite monitoring, therefore, there is a need to have adequate transport for the Department of Fisheries to sufficiently carry out extension and research on the lake and in some fishing villages.

7.4 Proposed Future Research Topics

The research study suggested the following areas for future research;

i. Fishers and marketeers attributed indiscriminate fishing to biomass reduction of *Limnothrissa miodon*, therefore, there is a need to research the Socio-economic Dimensions of indiscriminate fishing on Lake Tanganyika.

ii. Fishers and marketeers attributed the increase in the population of fishers and marketeers to the biomass reduction of *Limnothrissa miodon*, therefore, there is a need to research the Consequences of Anthropogenic Activities on Lake Tanganyika.

iii. Findings show that fishers harvest fish in breeding areas, thus, there is a need to research how best breeding areas can be protected.

iv. Findings show that Village Conservation and Development Committees were created to supplement the effort of the Department of Fisheries in conserving *Limnothrissa miodon*, thus, there is a need to research the Efficiency of Village Conservation and Development Committees to determine their efficacy.

v. Literature shows that there is no submission of catch returns among Kapenta fishers on Lake Tanganyika year in and year out for some years now, therefore, there is a need to frequently conduct Catch Assessment Surveys to determine the actual status of *Limnothrissa miodon* by approximating the numbers.

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APPENDICES

Appendix 1

Ethical Clearance

THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka10101 | Tel: +260-211-290 258/291 777
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APPROVAL OF STUDY

8th November, 2021

REF NO. NASREC-2021-SEP-009

George Kambonge
The University of Zambia
School of Natural Sciences
Department of Geography and Environmental Studies
P.O. Box 32379
LUSAKA

Dear Mr. Kambonge,

RE: "SOCIAL ECOLOGICAL DRIVERS AND DYNAMICS OF *LIMNOTHRISSA MIODON* OF LAKE TANGANYIKA"

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary Review	Approval No. NASREC-2021-SEP-009
Approval and Expiry Date	Approval Date: 8th November, 2021	Expiry Date: 7th November, 2022
Protocol Version and Date	Version - Nil.	7th November, 2022
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.
- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.
- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.
- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled "late submissions" and will incur a penaltyfee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.
- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO),both NASREC
- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.
- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.
- Filing a closing report (rather than just letting your approval lapse) is important as it assists NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.

- A reprint of this letter shall be done at a fee.

- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,

Dr. Mususu Kaonda

VICE CHAIRPERSON
THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES RESEARCH ETHICS COMMITTEE - IRB

cc: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies

Appendix 2

Sample of Unedited Interview Transcript

1. Demographic Characteristics

i. Gender of Respondents

ii. Age of Respondents

iii. Years in School

2. Drivers of the Decline of Kapenta

i. Causes of reduction of Kapenta

ii. Drivers of the decline of Kapenta

iii. Effects of decline of Kapenta

iv. Strategies to sustain Kapenta

3. Extension and Research

i. Extension and research taking place or, not

ii. Frequency of extension and research

iii. Types of extension received

iv. Significance of extension

4. Intervention of Decline of Kapenta

i. Government intervention to sustain Kapenta

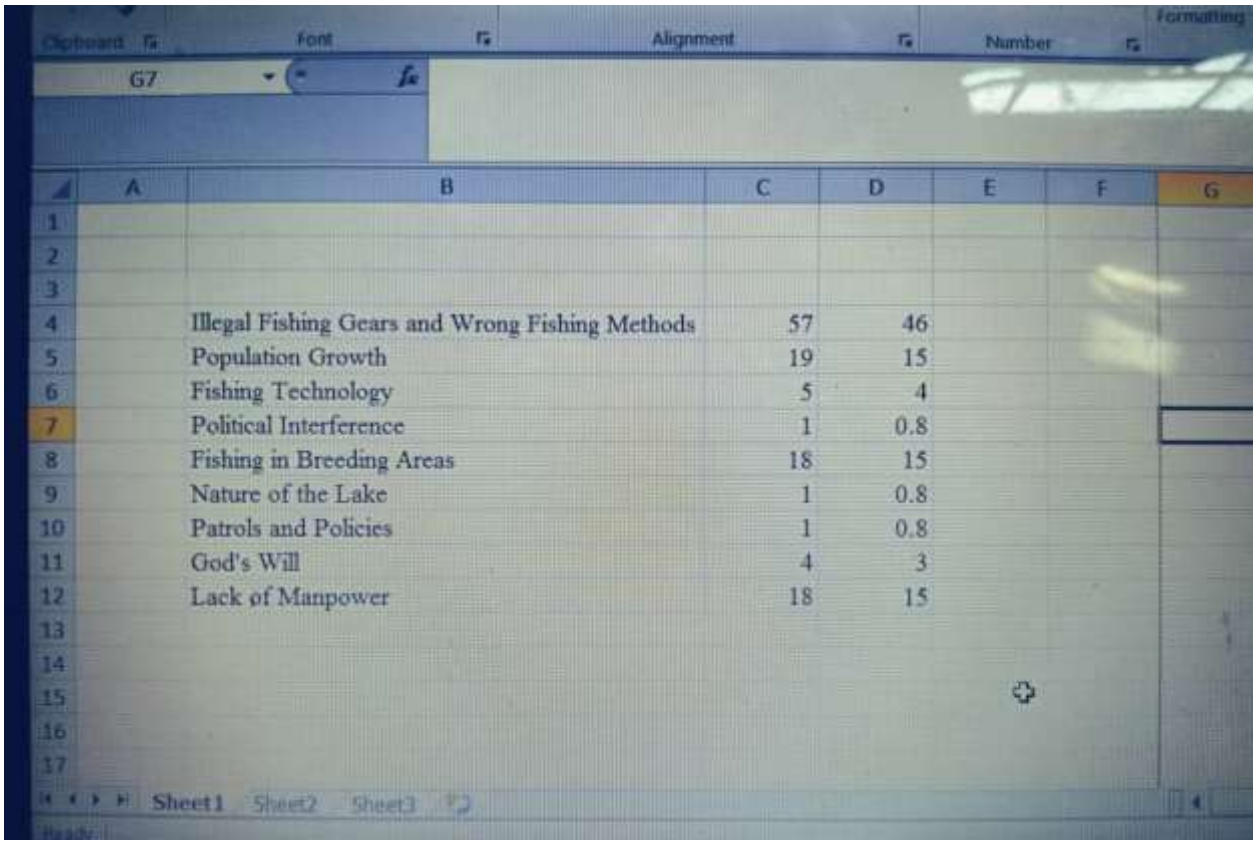
ii. Adequacy of intention of interventions

iii. Projects by government as intentions

iv. Government management approaches

Appendix 3

Sample of Analyzed Themes and Sub-themes



Illegal Fishing Gears and Wrong Fishing Methods	57	46	
Population Growth	19	15	
Fishing Technology	5	4	
Political Interference	1	0.8	
Fishing in Breeding Areas	18	15	
Nature of the Lake	1	0.8	
Patrols and Policies	1	0.8	
God's Will	4	3	
Lack of Manpower	18	15	

Appendix 4

General Respondents Questionnaire

Dear Respondent,

I am a final year student of the above named institution carrying out a research study on the above research topic. I wish to request for your timely co-operation by completing this interview guide and the information obtained through this interview schedule will be treated in absolute confidence and is for research purpose only.

01. Gender of respondent……

a. Male ☐ b. Female ☐

02. Indicate your Age

☐

03. Indicate the years attended in school

a. None ☐ b. Primary ☐ c. Secondary ☐ d. Tertiary ☐

a) Yes b. No

04. What are causes of the reduction of *Limnothrissa miodon* on Lake Tanganyika?

a. ……...…….

b. ……...…….

05. What are the drivers contributes to the reduction of *Limnothrissa miodon* on Lake Tanganyika?

a. Population of fishers and marketeers ☐

b. Indiscriminate Fishing ☐

c. Climate Change ☐

06. What are the effects of not sustaining *Limnothrissa miodon* on the fisher folk and traders?

a. …..……..…….....……..

b. ……..……..…….....……

07. What are the strategies that can be used to sustain *Limnothrissa miodon biomass*?

a. ……..……..……..……..……

b. ……..……...……..

08. Have you ever received extension services from government extension staff pertaining to sustaining *Limnothrissa miodon*?

a. Yes ☐ b. No ☐

09. How many times have you received extension services?

a. Monthly ☐

b. After 3 months ☐

c. After every six months ☐

d. Annually ☐

10. What type of extension services do you receive from government?

a. …….…….

b. ……..……...……..

11. Do you think provision of extension services by government can improve the sustainability of *Limnothrissa miodon*?

a. Yes ☐ b. No ☐

12. Has there been any government intervention to promoting the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. Yes ☐ b. No ☐

13. Has the intervention been adequate?

a. Yes ☐ b. No ☐

14. State the examples of projects of government that promote the sustainability of *Limnothrissa miodon*

a. ……..……..

b. ……

15. What do you think government should do to promote the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. Marine Transport ☐

b. Extension Staff ☐

c. Gear/methods Regulations ☐

d. Number of Fishers ☐

Appendix 5

Key Informants Questionnaire

Ministry of Fisheries and Livestock, Officer-in-Charge and Fisheries Staff

Name of key Informant :…….....

Your position :……..

Fish Harvesting Related Questions

01. What are the main causes of the biomass reduction of *Limnothrissa miodon?*

a. …….

b. ……..

02. What drivers contribute to the biomass reduction of *Limnothrissa miodon?*

a. …….....

b. ……..

03. What are the effects of not sustaining of *Limnothrissa miodon*?

a. …….

b. ……..

04. What are the strategies that can be used to sustain *Limnothrissa miodon?*

a. …….

b. …….

05. What types of extension services do you conduct on Lake Tanganyika*?*

a. ……..

b. ……..……

06. Do you think the provision of extension services by government can improve the sustainability of *Limnothrissa miodon*?

a. Yes ☐ b. No ☐

07. Has there been any government intervention to promoting the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. Yes ☐ b. No ☐

08. Has the intervention been adequate?

a. Yes ☐ b. No ☐

09. What do you think government should do to promote the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. ……..

b. …….

Appendix 6

Focus Group Discussions (FGDs) Questionnaire

Fishers and Marketeers

Name of key informant :…….....

Your position :……..

Fish Harvesting Related Questions

01. What are the main causes of the biomass reduction of *Limnothrissa miodon?*

a. ……

b. ……

02. What drivers contribute to the biomass reduction of *Limnothrissa miodon?*

a. …….....

b. ……..

03. What are the effects of not sustaining of *Limnothrissa miodon*?

a. …….

b. ……..

04. What are the strategies that can be used to sustain *Limnothrissa miodon?*

a. …….

b. …….

05. What types of extension services do you conduct on Lake Tanganyika*?*

a. ……..

b. ……..……..

06. Do you think the provision of extension services by government can improve the sustainability of *Limnothrissa miodon*?

a. Yes ☐ b. No ☐

07. Has there been any government intervention to promoting the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. Yes ☐ b. No ☐

08. Has the intervention been adequate?

a. Yes ☐ b. No ☐

09. What do you think government should do to promote the sustainability of *Limnothrissa miodon* on Lake Tanganyika?

a. ……..

b. …….…….

Appendix 7

Consent Notes

1.0 Introduction

You are invited to join an academic research focusing on Socio-ecological drivers and Dynamics of *Limnothrissa miodon* on Lake Tanganyika in Mpulungu District of Northern province of Zambia. In this study, the researcher intends to investigate drivers contributing to the biomass reduction of *Limnothrissa miodon*. Sustained *Limnothrissa miodon* can be a stepping stone to ensuring improved fish production which can create job opportunities for young people, generate income and promote food security within the district. The researcher wants to compile drivers contributing to the biomass reduction of *Limnothrissa miodon,* therefore, present findings to policy makers so that measures identified can be used to implement a policy that will see a viable fisheries subsector.

2.0 What the Research is all about

If you decide to participate in the research, there are a set of semi-structured questions relating to the biomass reduction of *Limnothrissa miodon* in the district that you will manage. The duration of attempting research questions will take 15 to 25 minutes. The purpose of the study is to conduct a survey through an interview schedule that will be shared with you. In this case, the researcher will be asking you questions and as you answer, the researcher will be recording your answers on questionnaires provided. The researcher will be visiting you occasionally if there will be some further clarifications needed.

2.1 The benefits of taking part in the research study

Hereunder are the benefits of taking part in this research study;

i. It will help you identify drivers contributing to the biomass reduction of *Limnothrissa miodon* and help you aspire to engage in cage farming as an alternative.
ii. It will report findings to other fishers on the effects of not sustaining *Limnothrissa miodon*.

2.2 The benefits to the community

Hereunder are the benefits of the research study to the community;

i. It will inform literature on drivers contributing to biomass reduction of *Limnothrissa miodon* and will attempt to bridge the gap between theory and practice.
ii. It will help academia understand drivers contributing to the biomass reduction of *Limnothrissa miodon* and it will further fuel discussions to address the problems.
iii. It will draw more attention to sustaining the biomass of *Limnothrissa miodon* and encourage researchers to come up with models, tools and techniques in assisting its sustenance.
iv. It will serve as a guide to would-be fishers to sustain the biomass of *Limnothrissa miodon*.

3.0 Your right as a participant in this research

In this research study, participation is voluntary. You have the right not to participate in the study and in the event that you decide to do so, you are at liberty to leave any time you feel like leaving. You also have the right to remain anonymous.

3.1 Confidentiality

Any sensitive issues you share with the researcher will not be disclosed to the third part unless if you say so. The researcher does not intend to criticize you for not sustaining the biomass of *Limnothrissa miodon*, but rather wants to understand drivers contributing to the biomass reduction of *Limnothrissa miodon* and reasons why fishers are not sustaining this natural resource. The contribution you will make in the research project will be vital.

4.0 Agreement

i. I agree to take part in the research study.

a. Yes ☐ b. No ☐

ii. I understand that my participation in the research study is voluntary.

a. Yes ☐ b. No ☐

iii. I agree to my interviews being recorded.

a. Yes ☐ b. No ☐

iv. I confirm that I have read/understood the information explained.

a. Yes ☐ b. No ☐

Signature :……

Date :……

Appendix 8

Request to Conduct Research

Ministry of Fisheries,
P.O BOX 23,
Mulobezi – Zambia.

May 21, 2020.

THE OFFICER-IN-CHARGE,
THE MINISTRY OF FISHERIES,
P.O BOX 420055,
MPULUNGU – ZAMBIA.

Dear Sir/Madam,
REF: REQUEST TO CONDUCT A RESEARCH STUDY ON DECLINE OF LIMNOTHRISSA MIODON.

Please refer to the above captioned matter

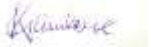
I am a postgraduate student of The University of Zambia, **Computer Number 19002076** currently pursuing Degree of Master of Science in Environmental and Natural Resources Management requesting to conduct a research study on fisher folks/traders on Lake Tanganyika of Mpulungu District of Northern Province of Zambia.

The research study entitled **"SOCIO-ECOLOGICAL DRIVERS AND DYNAMICS OF *LIMNOTHRISSA MIODON* ON LAKE TANGANYIKA"** is meant for academic purpose only and findings will be made public after completion of the research study for future researchers and other relevant organizations to act as a guide to their work.

Your office will, therefore, be kindly requested to be a guide toward this research study and any assistance in form of accommodation, provision of a motorbike and/or marine transport is appreciated in advance.

Finally, I am humbly looking forward to a favorable response to this kind request and thanking you in advance for your consideration to this matter.

Yours faithfully,



George Kambonge
0955/0966/0977 - 710962,
onekambongegeorge@gmail.com.

cc - Assistant Fisheries Director – Aquaculture (Fisheries Headquarters); Chilanga
cc - Officer-in-Charge; Mpulungu District
cc - Fisheries Officer; Mpulungu District
cc - Acting District Fisheries and Livestock Coordinator; Mpulungu District
cc - Fisheries Assistant; Mpulungu District

Appendix 9

Introductory Letter

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

P.O. Box 32379
Lusaka 10101, Zambia
E-mail: geography@unza.zm

Tel: 290603
Fax: (211) 253952/254406
Telex: UNZA ZA 44370

Date: 24/05/2021

To Whom It May Concern

Dear Sir/Madam,

RE: COLLECTION OF DATA

This is to certify that Mr./~~Mrs.~~/Ms. KAMBONGE GEORGE Computer No. 19002076 is a bonafide postgraduate student at the University of Zambia. He/~~she~~ is looking for useful information in relation to his/her research.

Kindly assist the student in any way possible and be assured that the information obtained will be used exclusively for academic purposes only.

Your assistance will be greatly appreciated.

Yours faithfully,

[signature]

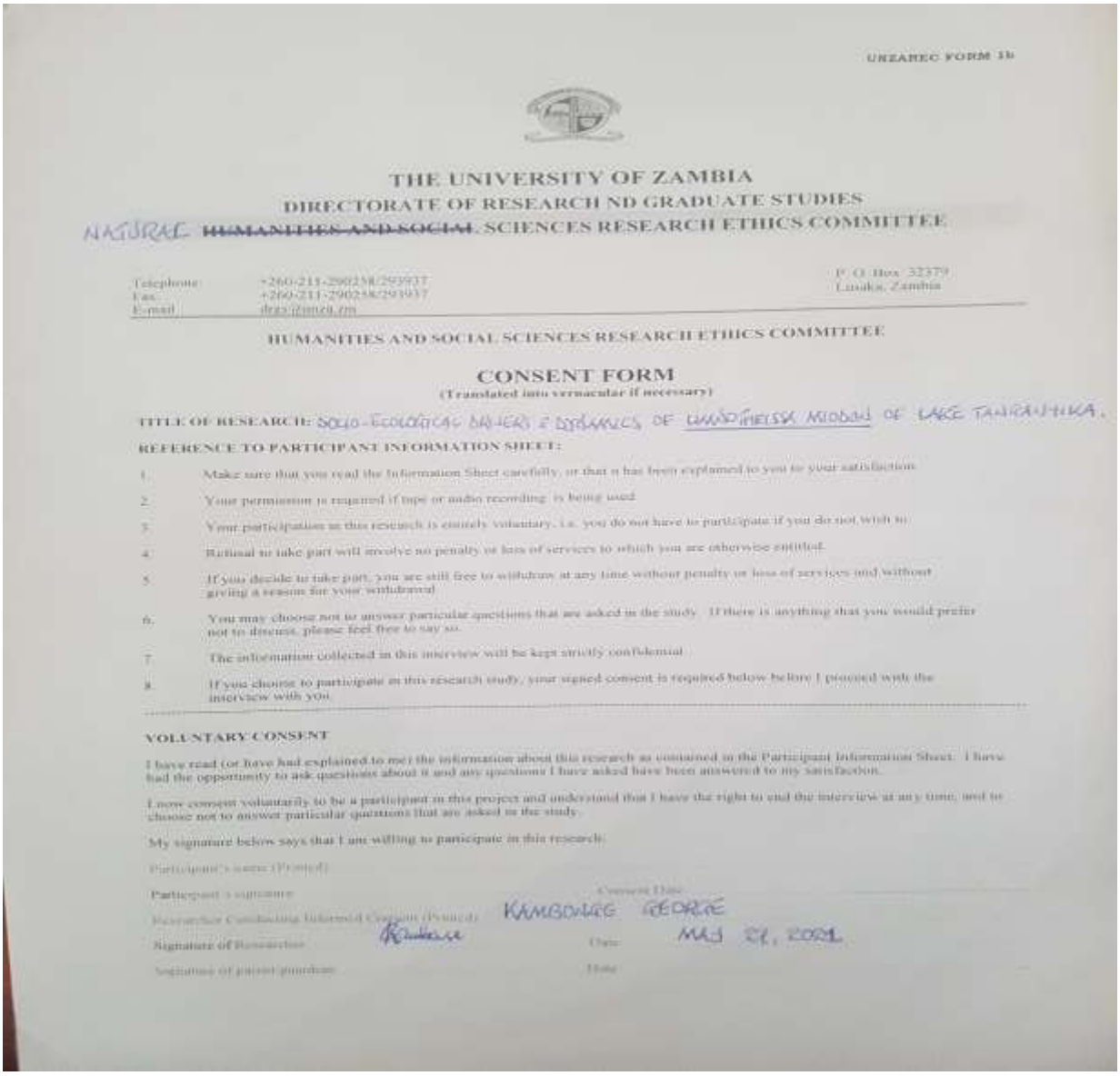
E. Imasiku (PhD)
HEAD, DEPARTMENT OF GEOGRAPHY & ENVIRONMENTAL STUDIES

REPUBLIC OF ZAMBIA
MINISTRY OF FISHERIES AND LIVESTOCK
24 MAY 2021
FISHERIES OFFICER
P.O. BOX ... MPULUNGU

noted
Tafilwe Sampa
Mpulungu

Appendix 10

School Consent Form



UNZAREC FORM 3b

THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH ND GRADUATE STUDIES
NATURAL ~~HUMANITIES AND SOCIAL~~ SCIENCES RESEARCH ETHICS COMMITTEE

Telephone: +260-211-290258/293937
Fax: +260-211-290258/293937
E-mail: dres@unza.zm

P. O. Box 32379
Lusaka, Zambia

HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE

CONSENT FORM
(Translated into vernacular if necessary)

TITLE OF RESEARCH: SOCIO-ECOLOGICAL BARRIERS & DISPARITIES OF LIVELIHOODS MODELS OF LAKE TANGANYIKA.

REFERENCE TO PARTICIPANT INFORMATION SHEET:

1. Make sure that you read the Information Sheet carefully, or that it has been explained to you to your satisfaction.
2. Your permission is required if tape or audio recording is being used.
3. Your participation in this research is entirely voluntary, i.e. you do not have to participate if you do not wish to.
4. Refusal to take part will involve no penalty or loss of services to which you are otherwise entitled.
5. If you decide to take part, you are still free to withdraw at any time without penalty or loss of services and without giving a reason for your withdrawal.
6. You may choose not to answer particular questions that are asked in the study. If there is anything that you would prefer not to discuss, please feel free to say so.
7. The information collected in this interview will be kept strictly confidential.
8. If you choose to participate in this research study, your signed consent is required below before I proceed with the interview with you.

VOLUNTARY CONSENT

I have read (or have had explained to me) the information about this research as contained in the Participant Information Sheet. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction.

I now consent voluntarily to be a participant in this project and understand that I have the right to end the interview at any time, and to choose not to answer particular questions that are asked in the study.

My signature below says that I am willing to participate in this research.

Participant's name (Printed)

Participant's signature — Consent Date

Researcher Conducting Informed Consent (Printed) KAMBOWE GEORGE

Signature of Researcher — Date MAY 21, 2021

Signature of parent/guardian — Date

Appendix 11

Observation Guide

Variables to be observed by the researcher

No.	Variables
1	Monofilament Nets
2	Fishers Seining
3	Mosquito Nets
4	Size of Kapenta
5	Water Level
6	Boats
7	Drying Racks