ASSESSING THE VULNERABILITY OF INLAND FISHERIES TO HUMAN-INDUCED PERTURBATION IN LAKE KARIBA FISHERY, ZAMBIA

by

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A Thesis

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Declaration

I declare that the content contained herein is my own original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Rhodes University will not infringe any third-party rights, and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

This dissertation includes two original papers published in peer-reviewed journals. The writing and the development of the papers (published and unpublished) were the principal responsibility of myself and, for each of the cases where this is not the case, a declaration is included in the dissertation indicating the nature and extent of the contributions of co-authors.

Date: October 2023

With reference to Chapter 4 [Transboundary Fisheries Management in Kavango–Zambezi Transfrontier Conservation Area (KAZA-TFCA): Prospects and Dilemmas. pages 78 to 122 of the dissertation], the extent of our contributions to the study were as follows:

- Imikendu Imbwae (Main Author) designed and conceptualised the research, literature search and review, data collection and analysis, and writing the paper.
- Shankar Aswani (Co-Author). reviewed, edited, and supported the conceptualization of the paper.
- Warwick Sauer (Co-Author). provided expert guidance on the methodology and structure of the paper.
- Clinton Hay (Co-Author) reviewed the paper and guided the scoping

Signature: Declaration with signature in possession of candidate and supervisor Date 30th October, 2023

Imbwae Imikendu

With reference to Chapter 5 [Socio-Economic and Environmental Challenges of Small-Scale Fisheries: Prognosis for Sustainable Fisheries Management in Lake Kariba Zambia, pages 123 to 166 of the dissertation], the scope of our contributions to the study were as follows:

- **Imikendu Imbwae** (Main Author) was involved in the field data collection, analysis, conceptualisation of the study, literature review and writing of the paper
- **Shankar Aswani** (Co-Author) gave advice on the scoping, reviewed and edited the paper.
- **Warwick Sauer** (Co-Author) guided the data analysis and the design of the paper.

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Abstract

Inland fisheries play a critical role in providing nutrition, employment, and ensuring food security among vulnerable groups in Lake Kariba. However, their value is usually undermined in developmental plans, and their contribution to a broader economic development is often undervalued. Over the past two decades, inland fisheries have stagnated. Simultaneously, there have been wide reports of increased fishing effort and declining trends in commercially valuable fish species. This has resulted into a wide socio-economic and environmental problems in various fishing communities. Lake Kariba Zambia, exemplifies this sustainability challenge, where fisheries resources and livelihoods are interlinked. A systematic peer review paper on this topic was documented, published and used for analytical work, focusing on governance and how it affects the utilization of the fisheries resources for food security and biodiversity conservation.

This study had four major objectives: (i) to identify threats to fisheries' productivity in Lake Kariba; (ii) to understand the socio-economic and environmental conditions of small-scale fisheries in Lake Kariba; (iii) to determine adaptation strategies adopted by small-scale fishers in light of the changing socio-economic and environmental conditions in Lake Kariba; (iv) to determine how management of fisheries has to change in response to the wide socio-economic and environmental challenges in the region. Using Ostrom's framework for analysing socio-ecological systems, various socioeconomic and environmental problems faced by fishing communities in Lake Kariba were examined to devise a sustainable fisheries management plan. The study employed explorative surveys, household questionnaires, key informant interviews, focus group discussions, observations, and a review of literature to elicit secondary data. A proportional quota sampling technique was used to draw a representative sample of 300 small-scale fishers and a typology was developed using a bivariate analysis. Chi-square was used to determine fishing effort over time. Using a curve fitting estimation

regression test, a trend analysis in fish production for the past thirteen years (13) years was performed.

Results did not show a significant decline in fish production over the past 13 years, yet experts and the fishers reported declining trends in valuable fish species. The finding of this study provides both practical and theoretical lessons that can enhance adaptive capacity and support sustainable livelihoods in the region. A fisheries sector policy is urgently required to guide governance process and coordinate a multi-sectoral perspective to fisheries management if socio-economic progression is to be attained.

Key Words: Inland fisheries, small-scale fishers, Lake Kariba, fisheries policy, biodiversity

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List of Abbreviations

CAS	Catch Assessment Surveys
CCRF	Code of Conduct for Responsible Fisheries
CPUE	Catch Per Unit Effort
DOF	Department of Fisheries
EUS	Epizootic Ulcerative Syndrome
FAO	Food and Agricultural organisation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GRA	Government Republic of Angola
GRN	Government of the Republic of Namibia

GRZ	Government Republic of Zambia
HEP	Hydro-electric Power
HLPE	The High-level Panel of Experts on food and nutrition
IPCC	Inter-governmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported and unregulated
KAZA-TFCA	Kavango Zambezi Transfrontier Conservation Area
LKFRI	Lake Kariba Fisheries Research Institute
MCS	Monitoring, Control and Surveillance
MEA	Millenium Ecosystem Assessment
MFMR	Ministry of Fisheries and Marine Resources
MSY	Maximum Sustainable Yield
RAFMS	Rapid Appraisal Fisheries Management System
RU-HEC	Rhodes University Human Ethics Committee
SADC	Southern African development Community
SDGs	Sustainable Development Goals
SES	Socio-ecological System
SNAP	Second National Agriculture Policy
SOP	Standard Operating Procedure
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea 1982
UNCTAD	The United Nations Conference on Trade and Development
WWF	World Wide Fund
ZAEDP	Zambia Aquaculture Enterprise Development Project

ZDA Zambia Development Agency

ZPWMA Zimbabwean Parks and Wildlife Management Authority

List of Publications and a manuscript

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Chapter 1: Introduction

1.1 Background

Inland fisheries, as defined by the Food and Agriculture Organization of the United Nations (FAO) as rivers, lakes, streams, reservoirs, canals and other land-locked waters bodies (FAO, 2014), are an important component of African fisheries. One-third of the world's total catch comes from these natural water bodies (DFID, 2002). Inland fisheries provide employment, income, food and nutritional security to vulnerable communities in a changing global landscape, particularly in low-income countries (Lynch, et al., 2016). Owing to their functional diversity, they play a complementary role in consolidating rising protein demand and improving incomes in supporting various ecosystem services for livelihood and biodiversity conservation. They provide individual economic security, cultural and recreational services to society, human well-being, capacity building, and knowledge transfer to the environment (biodiversity and ecosystem function as aquatic "canaries" (Lynch, et al., 2016; Muringai et al., 2022).

The sector supports the livelihoods of over 4.8 million people and contributes over 1.3% share to Africa's Gross Domestic Product (GDP) (Lynch, et al., 2015; Chan, et al., 2019; FAO, 2020). The United Nations Conference on Trade and Development (UNCTAD, 2016), reports that fish is among the most traded food product across the globe, focusing the spotlight of economic growth on the aquatic environments (Muringai, et al., 2022). Furthermore, inland fisheries are, in most cases, available in hard-to-reach places with insights from Lake Kariba Zambia, where very few other income-generating activities are found and can thus be a significant source of food and nutritional security in such places (FAO, 2014; FAO, 2020). Fish is said to be among the cheapest and most affordable source of animal protein for over 30% of a population of more than 200 million people in Africa (Tran et al., 2019; Obiero, et

al., 2019). Therefore, inland fisheries play a crucial role in attaining the United Nations (UN) 2030 Sustainable Development Goals (SDGs; see https://www.un.org/sustainabledevelopment/) more especially with regard to Zero Poverty (SDG 1) and No Hunger (SDG 2) (Lynch et al. 2020). The focus of this study is Lake Kariba, a Man made Lake supporting diverse economic activities such as Fishing, tourism and recreation.

Although inland fisheries in Africa are widely considered an important source of food security and livelihoods, particularly for the rural poor communities (FAO, 2020), the fisheries biodiversity and the ecosystems that they support are increasingly becoming vulnerable to multiple stressors, including habitat loss, overfishing, pollution, changing climate and the introduction of non-native fish species (Jackson, et al., 2016; Smith et al., 2017). Anecdotal evidence on the Lake Kariba fishery in Zambia shows that fish catches in the past two decades have been declining, demand has possibly exceeded supply (Kolding, et al., 2003; Tweddle, et al., 2015; FAO, 2019), and this has increased fear of the fishery's depletion. However, it is not clear whether this situation has deteriorated or not, and how fisherfolk have adapted to the socio-economic and ecological changes over time. A myriad of studies on this subject have not addressed the socio-economic effects of these changes to local communities (Mhlanga, 2009; Yuerlita, 2013). This has invariably impinged on the sector to unleash their potential contributions to mitigate the many challenges confronted by vulnerable groups (Muringai et al., 2022).

The High-level Panel of Experts on food and nutrition (HLPE) argue that the fisheries sub-sector has been subjectively isolated from other forms of food production systems in food security discussions, debates, and policy planning (HLPE, 2014). According to Ababouch and Fipi (2015), over 50% of fish stocks in West African countries are overfished, due to unregulated fishing practices as one of the major drivers of overfishing. This scenario threatens

not only the fisheries' biodiversity but also the socio-economic condition of small-scale fishers, particularly the food security status of fishing-dependent communities (Kapembwa, et al., 2022). A myriad of studies has shown that 65% of inland fisheries are highly or moderately threatened by an array of factors, both natural and anthropogenic (e.g., Collares-Pereira & Cowx, 2004; Lynch, et al., 2016; Sayer, et al., 2018; Wely, et al., 2020). However, overfishing, which reduces the value and quantity of fish yield and productivity and poor governance have been identified as the main causes in the decline of the highly commercially important fish species, (Hara, 2011; FAO, 2014; Hara & Njaya, 2016). In addition to overfishing, climate change has emerged as among the greatest threats to inland fisheries (Adam, et al., 2019). Several experts (Ndebele-Murisa et al. 2011; Ndhlovu, et al., 2017; Adama et al., 2019) have highlighted the biological consequences of climate change on fish reproduction (growth rate) and the ripple effects on livelihoods, food and nutrition security of vulnerable groups who may have limited food sources. These combined effects of these sustainability challenges especially in low-income countries, have been described by Friend et al., (2009), as 'songs of doom', a description that has stimulated debates and criticism over the current fisheries management practices which focuses more attention on biological studies to inform policy direction (Kulwijila, et al., 2016; WWF, 2020).

Current fisheries management practices and efforts are constrained by lack of socio-economic data which could be an essential component in understanding the dynamics leading to environmental decay in various freshwater ecosystems in Africa (Garcia & Charles, 2007; Wely, et al., 2020). Management decisions are mostly informed by biological studies based on maximum sustainable yield often referred as classical fisheries management practices. The application of these classic fisheries management approaches in tropical inland fisheries have been widely criticised by several experts (e.g., Mosepela & Kolawole, 2017; Mosepela, 2014) for their simplistic approach based on fish gear and mesh size restrictions. Such an approach

views complex socio-economic challenges from an ecological perspective discretely, undermining the socio-economic status of the fishers that may have a bearing on the fisheries resources. This has often resulted in a panacea solution which assumes 'a blue-print solution' for every environmental challenge, such as privatisation (Ostrom et al., 2007). The multiple factors that affect inland fisheries connect and affect livelihoods of fishers, leading to their vulnerability.

A better understanding of human-environmental interactions and how they lead to new developments can help build resilience and more effective interventions. Prognosis for sustainable fisheries' resource utilisation can only be meaningful if governance systems are designed to provide a balance between the need for socio-economic development and environmental conservation at large (MEA, 2005; Ostrom 2008).

There are basically four interrelated factors that may be useful in designing a sustainable fisheries' management system namely, economic, ecological, community, and policy (Adrianto et al., 2005). A sustainable fisheries management system is difficult to achieve from a single management perspective; it requires the integration of both science and social and ecological approach which may have an influence on the way communities respond to environmental problems (Charles, 1994; Ostrom, 2008). This suggest that human beings are part of an ecosystem. Analysing environmental issues from a social perspective alone, may lead to maladapted strategies which may further escalate into environment degradation (Smit & Wandel, 2006). Similarly, management decisions based on an ecological perspective alone may not be adequate enough to protect socio-ecological disturbances, such management approaches often result in panacea solutions, leading to unsustainable management strategies (MEA, 2005). Therefore, an effective management system for small-scale fisheries must take a multi-sectoral approach, drawing experiences from both social and natural sciences (Andrew & Evans, 2009). This is consistent with management strategies which provide for social,

economic and ecological aspects in fisheries management to ensure their sustainable exploitation (FAO, 1995; Ahmed, et al., 2013). Unfortunately, most of the regulations governing small-scale fisheries have focused more on conservation, paying little attention to mainstreaming poverty alleviation strategies (Chama & Mwitwa, 2020; HLPE, 2014), and so making small-scale fishers more vulnerable to the effects of fish decline (DFID, 2002). The systems of governance have thus often ignored the socio-economic needs of fishing-dependent communities (Allison & Ellis, 2001; Smith et al., 2005).

1.2 Statement of the Problem

The contribution of the Lake Kariba fishery to food and nutritional status has been widely acknowledged, but its critical role as a source of income to various actors in the country and the region has been too underestimated to translate into widespread recognition (SADC, 2019; FAO, 2022). The fishery contributes substantially to the regional economic status. Therefore, adequate management strategies are required to guarantee its long-term sustainability. During the past 30 years the Lake Kariba fishery in Zambia has experienced the most intense interlinked anthropogenic stressors (Magdza, 2010; Maulu & Musuka, 2019). There have been widespread reports of over-fishing, habitat degradation, destructive use of fishing gear, pollution, rapid urbanisation, human encroachment, hydro-power development activities, and the introduction of invasive fish species (Magadza, 2010; Madzudzo, et al., 2014; Tweddle, et al., 2015; Chifamba & Mauru, 2017). However, the existing management strategies appears inadequate to sustainably address the future needs.

The aquatic environment is exposed to a wider and deeper degradation at the catchment area, leading to water quality deterioration because of return flows and run-off from industrial, urban and agricultural activities in the area. The resulting accelerated erosion and sedimentation in the Lake has, in turn, damaged the littoral zones as the breeding ground for

pelagic fish species (Kolding, 2003; Magdza, 2010; Maulu & Musuka, 2019). The fisher community at large appears to have low adaptive capacity to cope with the many environmental challenges they face due to a number of socio-economic constraints including low income. Climate change has further exacerbated these socio-economic and ecological problems. As the planet warms, the alteration of functional response for most aquatic organisms including fish has been widely documented (IPPC, 2014; Maulu et al., 2021). Most of these aquatic organisms, like fish, are poikilothermic such that any abrupt change in temperature may negatively affect spawning, feeding habits, growth rates and distribution patterns (Collares-Pereira & Cowx, 2004; Magadza, 2011; Ndhlovu, et al., 2017; Maulu, et al., 2021). According to Brander (2010), the direct impact of climate change will discretely influence reproduction, growth and mortality. In addition, the aquatic biodiversity that fish rely on such as planktons is likely to be affected, with uncertain effects on catch potential. Fish species will probably shift their distributions as both warmer water species and colder water species are expected to move pole-wards (Beare et al., 2004). Very few studies have been done to guide conservation prescriptions in the area.

This narrative exemplifies Lake Kariba; depletion and water fluctuation of the Lake has caused further drastic changes in plankton productivity and reduced water supply for the hydroelectric power station (Tumbare, 2008; Magadza, 2010). Consequently, fish productivity and yield have constantly fluctuated, with some fish species reported to have become extinct, among them, *rheophilic Spp, Chiloglanis neumanii, opsaridium zambezense* and *Leptoglanis rotundiceps* (Karenge & Kolding, 1995; Kolding, et al., 2003; Maulu & Musuka, 2019). This has led to a loss of livelihood opportunities (Britz et al. 2015), and poses a threat to meeting the global and regional development goals including (SDGs) and subsequently Zambian's Eighth National Development Plan, which aims at improving rural livelihoods through the sustainable use of natural resources like fisheries. The existing situation has further threatened

the sustainability of fisheries biodiversity and the future of inland fisheries across the Agro-fisheries value chain.

If these environmental problems are not addressed, the ecosystem services that future generations acquire from fisheries biodiversity could be considerably compromised, leading to a wide socio-economic and ecological challenges (Ahmed, et al., 2013; Maulu & Musuka, 2019). The current management practices have largely failed to contain the many environmental problems faced by inland fisheries (Barkes, et al., 2001). The challenge could be that fisheries management practices in tropical inland fisheries are based on a few isolated case studies, which include estimates of the fishing effort, basic fishing gear, and mesh-size restrictions. Such management strategies have often resulted in simplistic solutions to complex problems thereby assuming a 'blueprint' for all ecological problems and a shortfall of social and economic data essential for human development and environmental sustainability (FAO, 1995).

The United Nations Sustainable Development Goals (SDGs), particularly SDG 17, have focused on strengthening partnership in the management of natural resources. However, in practice, community participation has remained moderate (Hambiya, et al., 2015; Hara & Njaya, 2016), thus limiting the use of local ecological knowledge to improve conservation prescription in fisheries resource management (Berkes et al., 2000). Local resource users still experience numerous challenges related to power relations, resulting in effective engagement of user participation in fisheries' resource conservation (Njaya, et al., 2011). Individual fish catch-maximizing strategies continue to supersede collective responsibility and, as a result, all the characteristics of 'the tragedy of the commons' exist (Hardin, 1968).

Policies often consider that riparian communities are homogenous, meanwhile livelihood strategies and adaptation strategies come in various forms (Neiland et al., 2000;

Brugere et al., 2008; Bene, 2009). There could be patterns of adaptation among the fishers; some households may diversify their livelihoods, while others remain mostly fishers; some may intensify fishing activities, while others resort to capture-based aquaculture. In this study, we address two major issues of fishers in the context of declining fisheries resources: which adaptation strategies do fisherfolk choose and practice in light of the current transformations? and what are the reasons for those decisions, and their concomitant outcomes? The focus on these issues will help generate essential information that can be used for future management and development of the fisheries resources in Zambia and the entire region.

1.3 Statement of objectives

In view of the above outlined problems faced by small-scale fishers on Lake Kariba, the overall objective of this study was to evaluate the nature of the small-scale fishing practices on Lake Kariba, examine their socio-economic conditions, and identify the environmental threats that may have negative effects on fisheries' biodiversity and the livelihoods. The study further assesses how small-scale fishers have adapted to the socio-economic and environmental changes over time and suggests possible interventions to protect the fishery from further deterioration. The thesis proceeds by documenting a systematic peer review paper on the role of institutions, governance and management of inland fisheries for analytical work as a chapter (4) and a detailed understanding of how these institutions affect the utilization of fisheries resources for food security and biodiversity conservation in the region.

Specific objectives of the study are:

i. To identify threats to fisheries productivity in Lake Kariba;
ii. To evaluate the socio-economic and environmental conditions of small-scale fishers in Lake Kariba

iii. To determine the adaptation strategies adopted by small-scale fishers in light of the socio-economic and environmental changes in Lake Kariba;
iv. To determine future management in response to the socio-economic and environmental changes in Lake Kariba;
v. To review the role of institutions in governance and management of inland fisheries in the region (Kavango-Zambezi Transfrontier Conservation Area), and how it affects the sustainable use of the fisheries resources.

Research questions

i. What are the perceived key threats to fisheries productivity in Lake Kariba?
ii. How are the socio-economic and environmental conditions in the Lake Kariba fishery affecting small-scale fishers?
iii. How have small-scale fishers adapted to the socio-economic and environmental changes in Lake Kariba?
iv. How will the management of the Lake Kariba fishery have to change in response to the socio-economic and environmental changes?
v. How have existing fisheries institutions, governance and management practices affected conservation and the sustainable use of the fisheries resources in Lake Kariba and the entire Zambezi River catchment?

1.4 Significance of the Study

The significance of this study can be conceptualised in three dimensions, based on its contribution to conservation practice, literature and policy design and formulation.

Fisheries management interventions can be effective with better understanding of the fishing-dependent communities (FAO 2005). Socio-economic data, especially in fishing communities is often difficult to find (Béné, 2009; WFC, 2004), and the limited understanding

of the socio-economic attributes of fishing communities is a social dilemma for fisheries resource managers when weighing the issues of conservation versus food security. The importance of addressing this area of concern was a motivation to generate data on the various socio-economic aspects of the fishing communities in the Lake Kariba fishery. (see chapter 5 and 6). Zambia has an estimated 15 million hectares of water in the form of lakes, rivers, swamps, streams and reservoirs, accounting for about 40% of inland fisheries in Southern Africa (Musumali et al., 2009). According to FAO (2014), the fisheries of Zambia are categorised into eleven (11) main fisheries; four (4) are palaeo-evolutionary linked to the Congo River basin, and seven (7) are linked to the Zambezi River basin. This suggests a conducive environment for thriving inland fisheries and aquaculture development. However, inland fisheries in Zambia and the region at large are somewhat poorly developed and are characterised by weak management institutions to guide governance processes (Weyl, et al., 2007; Mosepela & Kolowole, 2017; Weyl, et al., 2020; Kapembwa, et al., 2022). Therefore, this study aims to stimulate policy debate that will provide a specific and context management system in the region. This will enrich and add value towards the development of a new policy direction in the utilisation of the fisheries resources for food security and biodiversity conservation in Zambia and several other countries in the Southern Africa Development Community (SADC). Currently, Zambia and many other countries in the region do not have a fully developed fisheries sector policy to guide governance processes and conservation prescriptions (Kapembwa, et al., 2022). The existing fisheries policy in the Zambia at the time of this study was basically a statement from the National Agriculture Policy (NAP, 2015-30), which focuses on maximizing fisheries production to meet the national demand (Kefi & Mofya-Mukuka, 2015; Nyikahadzoi, et al., 2017).

More focused research is needed to guide the advancement of a new policy direction in the region. The significance of this thesis illustrates, with examples, the need for an inland

fisheries sector policy in the region, particularly to strengthen governance processes through strong partnership and stakeholder involvement (Chama & Mwitwa, 2020; Weyl, 2021; Kapembwa et al., 2022). Furthermore, the study will help bring about a dialogue among primary, secondary, and tertiary stakeholders such as the fishing community, traditional leaders, non-governmental organizations and research institutions. Such debates are vital for improved conservation practices to enhance food security in Lake Kariba and beyond. In addition to the fisheries policy, the overall objectives of FAO's (2003) 'Ecosystem based approach to fisheries' seeks to implement the sustainable utilisation of natural resources by promoting justifiable socio-economic development (Wely, et al., 2020). The use of social, economic and environmental research to provide management advice to this effect is cardinal in understanding the human-environmental interaction in a socio-ecological system (FAO, 2003; Aswani, et al., 2013; Wely, et al., 2020).

Despite Zambia's rich fisheries endowment, the sector is characterised by over-exploitation and high fishing pressure that has led to decreased fish catches and a decline in most fish species of economic value, particularly the *Oreochromis* fish species (Chifamba & Mauru, 2016; Mauru & Musuka, 2018). Major challenges associated with inland fisheries include the use of illegal and destructive fishing methods; loss of critical habitats due to environmental degradation resulting from pollution; unsustainable farming practices, and sporadic outbreaks of infectious fish diseases, such as *Aphanomyces invadans* (Epizootic Ulcerative Syndrome [EUS], and high post-harvest losses due to inadequate marketing infrastructure (Cole, et al., 2018). In developing inland fisheries, Zambia has a window of opportunity to redesign its inland fisheries in a sustainable manner without undermining their potential to provide food security and the welfare of the people surviving on them. This requires knowledge of the conditions that lead to the success and failure of inland fisheries development,

and a detailed understanding of the livelihoods conditions of people already relying on these resources. This study, endeavours to generate such information.

This study contributes to the literature on the influence of social and economic conditions of small-scale fisheries; a more comprehensive study of environmental changes affecting the livelihoods of small-scale fishers, reporting on descriptive analyses and attempts to address particular concerns regarding limited livelihoods and non-availability of socio-economic information in the study area. A myriad of studies on this topical study is more focused on fish stock assessment to inform management decisions (Kolding et al., 2003; Nyikahadzoi, 2023). These studies have often suggested conservation based on a classical fisheries management perspective as the most suitable solution for fisheries problems in Lake Kariba (Kolding et al., 2003; FAO, 2007; Musumali, 2009; Elender, 2014; Mosepela, 2014; Mosepela & Kolawole, 2017 Nyikahadzoi, et al., 2017). However, the results of such studies are constrained by lack of livelihood diversity and resource dynamics for small-scale fishers (Chama & Mwitwa, 2020). Inland fisheries in Africa are often characterised by a diverse range of factors within the environment in which they exist and by complex social and cultural societies (Coates, 2002). The lack of data and the poor understanding of the social and economic aspects of fishers as a key stakeholder have driven the desire to conduct this study. To fill the data gap, the study highlights some of the emerging environmental challenges arising from the increased number of resource users. These are associated with the decline of indigenous fish populations due to negative interactions (hybridisation, predation and competition) with introduced fish species characterised by user conflicts resulting from contested fishing grounds (Mhlanga, 2009).

A solution that will reduce and prevent unsustainable resource exploitation is required to protect and prevent the fishery from falling into wider and deeper environmental degradation. A myriad of micro studies highlighting challenges associated with adaptation to

environmental changes over time are significant because macro-level predictions may not give appropriate solutions to suit the Lake Kariba context, as they often lack specific and context information (Lemos, et al., 2009; Singh et al., 2015; Maptsa, 2020). While it is recognised that people who depend on fresh water ecosystems have adapted to the past recessions, the population increase, climate change, user conflicts and the emergence of the COVID-19 pandemic have constrained management efforts (Hackenberg, et al., 2022). There is a dearth of empirical data explaining the dynamics of adaptation strategies over time; such multi-locality information has been widely acknowledged to strengthen resilience in governance and management systems (Mapitsa, 2020). More importantly, Tumbare (2008) observed discrepancies in the provision of improved socio-economic conditions for the displaced victims (Tonga/Korekore ethnic group) during and after the construction of the dam wall that resulted in the creation of the Lake Kariba fishery in the 1950s. The highlights of this historical event in this study are an important contribution to institutional memory and future resource governance and management practices. Some of the reform that occurred particularly in the land tenure system from local people to state ownership resulted in loss of access rights over natural resources by local people (Mhlanga, 2009), Such information is essential for conservation and future policy direction in the study area (Mhlanga, 2009; Mapitsa; et al., 2020). Although Lake Kariba is among the most studied lakes in Africa (Anon, 1992; Kolding, 1994; Karenge & Kolding, 1995; Maulu & Musuka, 2018), previous studies by various scholars in the area weakened the traditional and contemporary achievements of the indigenous people and ruined prospects for further development along indigenous lines (Mhlanga, 2009). Without validation of social changes in the Lake Kariba socio-ecological system, local knowledge will not be acknowledged in state-led interventions or civil society organisations (Haughes, et al., 2012).

The study comprises of two peer-reviewed journal articles which have already been published and a manuscript in preparation (policy brief). Chapter 4 of the Thesis is a peer-reviewed journal publication entitled 'Transboundary fisheries management in Kavango Zambezi transfrontier conservation area (KAZA) Prospects and Dilemmas'. The Chapter is published in MDPI. https:// doi.org/10.3390/su15054406 by *Sustainability*. It systematically reviews the existing fisheries governance and management approaches in Zambia and four other countries sharing the Kavango-Zambezi transfrontier conservation area (KAZA). This Chapter is essential for a detailed understanding and analysis on the role of institutions in governance and management of inland fisheries in the region. More emphasis in this Chapter is on how institutions of governance affect the utilisation of fisheries resources for food, nutritional security and biodiversity conservation in a transboundary common pool resource to which Lake Kariba is a part. Chapter 5 of this study is also a peer-reviewed publication addressing the key objectives the study (Data Chapter) entitled 'Socio-economic and environmental challenges of small-scale fisheries: prognosis for sustainable fisheries management in Lake Kariba, Zambia', https://doi.org/ 10.3390/su15043179. The work was originally published by MDPI, *Sustainability.* The chapter highlights the socio-economic and environmental conditions of small-scale fishers in the face of environmental changes, including declining fisheries resources, due human induced perturbations. It further highlights future responses and provides evidence of how fisherfolk have adapted to the changes over time. This information is important for future conservation of fisheries' biodiversity in Lake Kariba and the region at large.

Chapter 6 of this study presents a summary of the study towards a policy brief; the chapter summarises the major findings of the study to provide for policy recommendations that are context and specific in the region. The information generated in the data Chapter and review

publications is useful for future scholarly work and better decision-making processes for wider socio-economic development at both national and regional levels.

1.5 Scope and Limitations of the Study

The focus of the study was to better understand the vulnerability of inland fisheries with insights from the Lake Kariba fishery and its riparian communities in the context of social-economic and environmental changes. The study identifies the threats to fisheries productivity and livelihoods of small-scale fishers. While the results of the study contribute to literature and policy formulation to address complex socio-ecological aspects of the fishery, some data gaps still require to be updated from this study. The study did not carry out actual ecological experimental gillnet surveys of the fishery resources. This may limit conservation measures; new ecological data is required. Some of the ecological information was collected and cited from secondary sources such as reports from the Department of Fisheries (DOF), and peer-reviewed papers. Furthermore, this study did not cover the whole fisher population in the area, because of budget constraints and time limitations. Such limitation may not give the accurate and updated ecological needs to guide policy and provide literature.

1.6 Dissertation Overview

The Thesis is made up of six (6) chapters. In Chapter 1 a brief description of the research background is outlined, and a statement of the problem, key research questions and research objectives, significance of the study, scope and limitation of study is presented. The study further highlights the importance of small-scale fisheries to social and economic development, particularly in low-income countries of Africa and Asia. Additionally, the study discusses existing challenges and opportunities associated with inland small-scale fisheries. Chapter 2 of the thesis presents the literature review, concepts and theories relevant to management of inland fisheries and their implication in least-developed countries.

Chapter 3 presents the methods for data collection, sampling design and data analysis. The study is grounded on the conceptual framework for analysis of social and ecological systems in natural resources management which was developed by Ostrom (2009). This chapter further indicates the methodology used for each of the empirical papers, particularly Chapters 4 and 5 which are stand-alone papers. This study used a paper-based approach for Chapters 4, 5, and 6. Each of these chapters adopted the form of a journal peer-reviewed paper to summarize the study and address the objectives and disseminate literature on the topic of study. The major focus was to assess the vulnerability of inland fisheries focusing on the socio-economic and environmental challenges of inland fisheries with insights from Lake Kariba.

Chapter 4 of the thesis presents a published systematic peer review paper on the role of institutions, governance and management of inland fisheries in southern African, particularly countries within the Kavango-Zambezi River system (KAZA) of which Lake Kariba fishery is a part. The chapter discusses the current fisheries management approaches in the region and its impact on the utilization of the fisheries resources for food security and biodiversity conservation. This chapter addressed objective number five which aimed at reviewing the role of institutions governance and management of inland fisheries in the region. This review paper was documented for analytical work and a detailed understanding on governance and the role of institutions in the management of inland fisheries particularly, transboundary fisheries to which Lake Kariba is linked. Institutions of governance in the region have a bearing on the sustainable use of fisheries resources for food security and biodiversity conservation. Institutions determine access/exclusion and utilisation of the fisheries resources. A myriad of studies has demonstrated that inland fishing communities are often constrained by institutions (Agrawal, 2002).

Chapter 5 of this study is a data chapter in which the overall results of the study are analysed and presented. The Chapter provides a deeper analysis on the vulnerability of the

inland fisheries in the context of socio-economic and environmental challenges of small-scale fisheries in Lake Kariba. It highlights an array of factors threatening the fisheries biodiversity and subsequently the future of the small-scale fishing industry to envision a sustainable fisheries management plan. The sixth chapter is a policy brief, which summarises the major findings of the study and their implications, with the key message illustrating the need for a sector fisheries policy to guide governance processes and a well-coordinated institutional framework. The brief gives a snapshot of relevant insights and policy recommendations for such a policy.

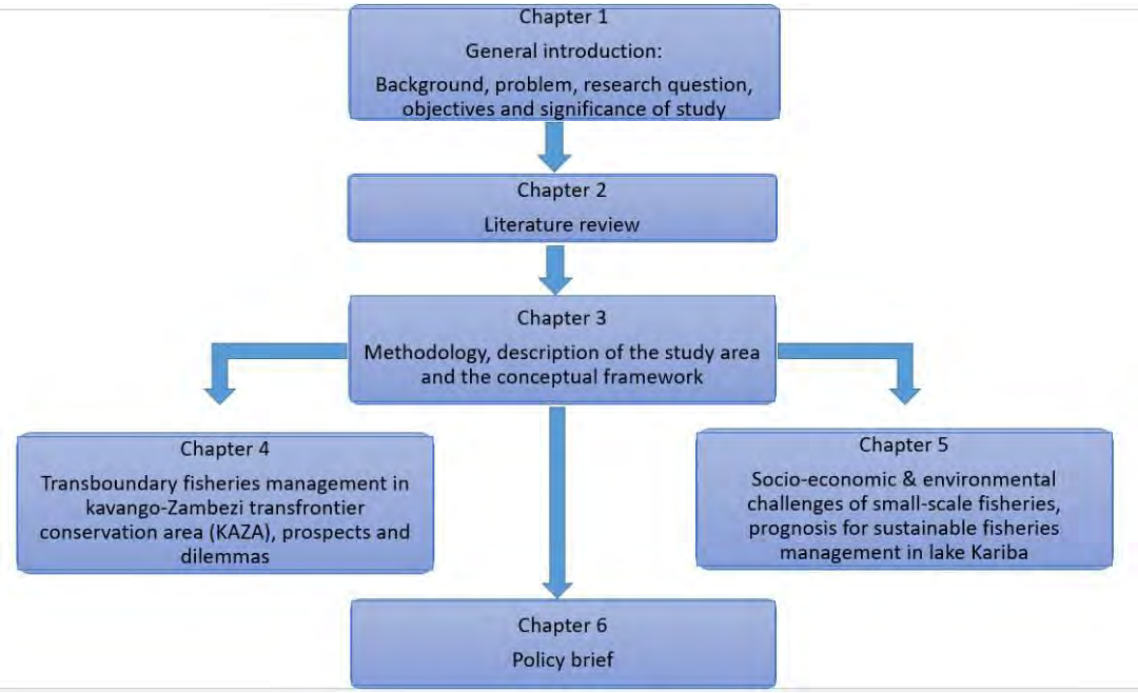

Figure 1.1 Schematic design of the study

1.7 Chapter Summary

This chapter has briefly outlined the research background, problems, major research questions and research objectives, the rationale of the study, and presents the scope and limitations of the research. The chapter puts into context the socio-economic relevance of small-scale fisheries to development, in particular vulnerable communities in developing countries, and the current

challenges related to inland small-scale fisheries. The interest to understand the potential of the inland fisheries sector is increasing with a view to examine the best conservation practices to protect the resource from depletion.

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Chapter 2: Literature Review

One of the most pressing challenges facing humanity in the 21st century is the sustainability challenge associated with natural resources management such as fisheries, forests, and water resources, together with the threat posed by massive climatic changes (McCarthy, 2002; Oggero, et al., 2013). Failures attributed to population growth, market-oriented policies and insufficient knowledge of the processes that lead to improvements in or depletion of these resources is often limited (Agrawal, 2003; Ostrom, 2009). This creates difficulties in managing these resources in a sustainable manner (Bailey & Jentoft, 1990). Furthermore, the management aspect of inland capture fisheries has often been sidelined in global food production policy debates owing to poor documentation and inaccurate production estimates (Lynch et al., 2016; Weyl et al., 2020). Despite being an important source of food security and livelihoods, particularly for the poor in rural communities, a substantial proportion of inland fish catch is 'hidden' and unreported (Thorpe, et al., 2018). The value attached to inland fisheries as a last resort of economic activity stimulates a discussion in the context of their vulnerability, importance and characteristics. This chapter explores the socio-economic aspects of small-scale fishers' livelihoods and the challenges associated with the sector. The main focus is to better understand the relationship between the declining fisheries and various socio-economic factors operating in Lake Kariba. Additionally, the chapter highlights some of the theories and concepts related to the governance and management of inland fisheries around the world, especially in the low-income countries of Africa, Asia and Latin America.

2.1 Socioeconomic importance of inland fisheries

A wide range of research (SADC, 2019; Chimatiro, et al., 2022) suggests that inland small-scale fisheries in Southern Africa support over three million people and significantly contribute to the wellbeing of humans through a range of various cultural and socio-economic gains, and

ecosystem services that directly contribute to the Sustainable Development Goals (SDGs) (Lynch et al., 2020; Chimatiro, et al., 2022). These socioeconomic benefits are very important in a region that is engulfed with multiple socio-economic problems including extreme poverty, lack of alternative livelihoods and acute malnutrition (SADC, 2021). Globally, inland fish production is estimated at 11.6 million tonnes, most of it generated by small-scale fishers in the least-developed countries (SADC, 2021). The sector plays a crucial role in poverty alleviation, sustaining livelihoods, addressing food security, and driving socio-economic agendas for most rural communities in developing countries (FAO, 2020). In addition, the non-market value, such as sport fishing and catch-and-release fishing, integrates well with the tourism sector, generating employment opportunities for various fishing communities across the continent (Whande, et al., 2006). Although inland fisheries data is conservatively reported, owing to insufficient data in most of the developing countries, sport fishing and recreation value generates about US$ 64 billion worldwide and drives employment opportunities across the value chain (Thorpe et al. 2018). While inland capture fisheries have great potential to generate income and provide employment opportunities along the Agro-fisheries value chain, their recognition in decision-making processes has usually remained low (Arlinghaus et al., 2019; Potts et al., 2019).

Inland fisheries are frequently downplayed – not entirely abandoned – but under-valued as a contributor to gross domestic product (Musumali, et al., 2009). Several factors are attributed to this, including those that are related to institutional lapses and policy failure and processes to advance the sector (Friend et al., 2009; Mosepela & Kolowole, 2017). The fisheries sub-sector, including inland fisheries, is among the food production systems identified by the Food and Agricultural Organization (FAO) of the United Nations for its important contribution in promoting socio-economic development, enhancing nutrition, food security, and improving the livelihoods of marginalized segments, particularly in least-developed

countries (Bene, et al., 2016; Chan, et al., 2019). Furthermore, current trends in food production systems suggest that inland fisheries are a nutrient-dense source of food for many nutritionally vulnerable and impoverished communities in sub-Saharan Africa (SSA), especially women, infants and those affected by HIV/AIDS (HLPE, 2014; Chan, et al., 2021). According to Marinda et al. (2018), the contribution of fisheries to nutritional status among Zambian children who regularly consumed fish and fish products showed they were in a better nutritional condition with fewer chances of stunted growth. A small pelagic fish species, like cyprinids which are abundant in the sub-Saharan Africa, have a high degree of essential nutrients, such as vitamins B12 and A, zinc and iron, all of which are critical for regeneration, growth and development, brain function, and maintenance of the central nervous system (Lynch, et al., 2015; Muringai, et al., 2022). Small pelagic fish from inland are consumed whole; consequently, nutrients concentrated in the bones, heads and viscera mitigate several human health deficiencies to address 'hidden hunger' (malnutrition) which presently accounts for a least one third of pre-maternal deaths in the sub-continent (Kolding et al., 2019).

Inland small pelagic fish value chains are gender inclusive, providing employment opportunities to women through processing and post-harvest business. Inland small-scale fisheries are essential to food sovereignty worldwide; they provide the last resort in any case where a primary source of income fails due to economic meltdown, natural disaster, or war (Lynch, et al., 2015). These fisheries provide alternative livelihoods and serve as safety-nets to supplement sources of income and employment. Awareness of their value compelled the FAO of the United Nations to recognise inland fisheries as an essential component of food production (FAO, 2005). While inland fisheries are crucial in addressing nutritional security among the vulnerable communities in Africa, malnutrition remains a huge and growing socio-economic problem in the sub-continent (Benson, 2008); it is within this framework that inland small-scale fisheries can be enhanced to advance the socio-economic agenda of impoverished

fishing-dependent communities and improve food security concerns across the African landscape. According to the FAO (2008), fish production from small-scale inland fisheries in Africa is dominated by the domestic market, providing food security for subsistence small-scale fishers particularly (Akpaniteaku et al., 2005). In spite of this significant role, the failure to generate and harness the resource for food security is a 'missed window of *opportunity' for poverty eradication, especially among the under-privileged rural communities in developing countries. Weak policies and poor understanding of the value of inland fisheries as a viable contributor to gross domestic product (GDP) has resulted in low recognition, hence the fisheries sector often appears as a sub-component under crop agriculture in the international classification index (Musumali et al., 2009; Kefi & Mukuka-Mofya, (2015), subjecting fisheries a low deal in policy formulation and reforms and as a viable food production sector.

Despite this oversight, inland fisheries still have the potential to enhance the sustainability of aquatic biodiversity and the development of inland aquaculture, particularly in the Lake Kariba fishery (FAO, 2019; Velde, et al., 2022). In the recent past, fish production figures from aquaculture in Zambia have risen exponentially from 12,988 metric tonnes in 2012 to 45,670 metric tonnes in 2020 (FAO, 2023). A substantial contribution of this has been attributed to inland aquaculture on Lake Kariba, a trend that has set a positive trajectory for employment opportunities among women and the youth who are under-privileged owing to lack of employment opportunities (FAO, 2023). The trend is of great importance in sustaining the socio-economic status of rural communities who depend on the abundance of fisheries biodiversity (Genschick, et al., 2017; Bannett, et al., 2021). Youth unemployment, and the future of job opportunities is becoming a global concern, and inland fisheries, through inland aquaculture, offer possible options to address youth unemployment and stimulate a viable sub-sector, especially in low-income countries like Zambia, where 75% of the people are poor and lack formal employment (CSO, 2014; Chan et al., 2021).

While this chapter highlights the potential and socio-economic contribution of inland fisheries to the transformation of food systems globally, the sector has remained increasingly elusive, slipping off global and regional development agendas (Friend et al., 2009). This elusiveness has been largely attributed to the lack of science-based research to inform the direction of private and state-led policy in decision-making and investment planning strategies (FAO, 2012; Chimatero et al., 2022). To date, there has been little or no readily available estimate investment and possible returns for fish production in Africa that can be used for policy extrapolation and debates with regard to the future of inland fisheries (Chan et al., 2021). The FAO (2012) report suggests that Africa has the second highest poor fish catch returns at 68%, after Oceana which stood at 78%. This challenge is characterised by poor funding and low staffing for effective monitoring, control and surveillance (MCS), especially in low-income countries (WorldFish Centre, 2007; Njaya, 2011). Inland fisheries have been acknowledged to be among the 'green food' movement, with sustainable exploitation of inland fish having relatively few environmental implications compared to other food production systems, like crop agriculture, which is often highly mechanized (Orr et al., 2012). The low mechanization nature of inland fisheries for consumption and harvest indicates relatively low dependence on fossil fuels for navigation and expedition during fishing activities. The potential of inland fisheries to provide a daily income for rural households has been described by Bene et al., (2009), as 'bank in the water'. Inland fisheries play a critical role in the socio-economic development of rural livelihoods through income generation and employment opportunities (Neiland et al., 2000), often characterised by spatial and temporal differences that are highly scattered along riverine areas, with multiple fish species assemblage fishers using diverse fishing gears and methods of operation. Small-scale fishers are not only involved in fishing, but they engage in other forms of livelihood strategies. (Allan et al., 2005).

These characteristics confirm the heterogeneous nature and complexity of inland small-scale fisheries which are supposed to be taken into consideration for more appropriate fisheries management strategies (Neiland et al., 2000; Tzanatos et al., 2005). Lack of adequate information, coupled with the complex socio-economic conditions in rural fishing communities, have led to poor management, resulting in marginalisation of the sector. Inland fisheries are marginalised mostly because of their geographic location in the remote areas which isolate them from the spheres of political influence (Pauly, 1997). Marginalisation of the sector is evident in a poor road network, lack of credit facilities, and poor infrastructure in the remote rural areas.

In comparison with large-scale commercial fisheries, inland small-scale fisheries are characterised by low technology and very little capital investment (Sowman, 2006). This results in low fish production because fishers use smaller, non-motorised fishing boats that are often operated by a family crew (Kent, 1997; Abdullah, 1994). Acknowledging the socioeconomic importance and benefits derived from inland fisheries is crucial for effective management and development of the sector. Unfortunately, the assessment of services provided by inland fisheries is poor and often undervalues them; consequently, small-scale fishing receives a low deal in comparison with other food production systems (Musumali, et al., 2009).

2.2 Vulnerability of inland fisheries in developing countries

Inland fisheries are vulnerable to a wide range of stressors, including overfishing, habitat fragmentation, and altered flows due to urbanisation (SADC, 2022). The interactive and synergistic effect of these pressures, including climate change, leads to environmental and socio-economic challenges, particularly among the fishing-dependent communities whose livelihoods are derived from the fisheries resources (Velde et al., 2022). The most frequently cited description of vulnerability is one expounded by Chambers (1989), who describes

vulnerability as “exposure to eventualities, stress, and uneasy to cope with them”. Vulnerability is usually measured in two dimensions: the external (the shocks, risks, or stressors) and the internal (the failure of a system to respond to perturbations). According to Leichenko and O’Brien (2002), the patterns of vulnerability in various fishing communities are increasingly becoming more dynamic due to the rapidly changing environment. In a similar way, the face of Lake Kariba in Zambia is increasingly changing due to multiple factors, including land-use change, environmental degradation, pollution, climate change and the emergence of multiple resource users. The inadequate understanding of how these factors interact has often resulted in ecological disturbances which, in some cases, are non-reversible (Garcia et al., 2003). Lake Kariba fishery exhibits this sustainability challenge where natural resource exploitation by multiple users has remained a subject of competing claims with ramifications for local livelihoods. According to the FAO (1999), evaluation of inland capture fisheries shows that most of the inland fisheries which depend upon natural stock reproduction are declining and are overfished at their biological limit, and that the key factors exerting pressure are interrelated.

Generally, multiple factors affect the productivity of inland fisheries; overfishing may not always be the only major threat, but in combination with other environmental stressors such as pollution and plant and animal species introduction (Allan et al., 2005; Velde et al., 2022). The full knowledge of how these socioeconomic and environmental challenges are perpetuated is fundamental for the application of appropriate interventions in a socio-ecological system, particularly in rural areas where job opportunities are limited. Most inland fishery areas are vulnerable because of the open-access attributes orchestrated by contemporary management practices that have developed over time. Owing to the lack of adequate policies to define governance processes, the roles and function of the sector in advancing socioeconomic

development have become dysfunctional assemblages of fragmented governance systems (Mhlanga, 2009; Mosepela & Kolawole, 2017).

The potential of inland fisheries to provide food security, income, employment and health benefits has been hampered by insufficient environmental sensitisation, lack of research, inadequate extension activities, low investment in the sector, coupled with unsustainable fishing practices, such as the use of meshless nets (Tweddle et al., 2015). Furthermore, the lack of fisheries' statistical data in most inland fishery areas has often resulted in extrapolation of unreliable fisheries' statistical data (WorldFish Centre, 2007). In most cases, these institutions are under-funded, with very low capacity to enforce and implement policy and regulations which are not appropriately coordinated among the various stakeholders. (Hecht et al., 2019).

2.3 Vulnerability of Inland fisheries in the context of climate change

The subject of climate change has been widely reported and examined in literature and policy debates (Muringai et al., 2020; Ndhlovu et al., 2017). However, the salience of adaptation mechanism within contemporary policy making is regularly unguided, leading to failure to cope with likely future impacts of climate change (Taylor, 2014). Some of the effects of climate change are beyond the proliferation and spread of invasive fish species, with impacts similar to those observed for species introductions, such as shifting distribution of fish species and changes in species composition (Lind et al., 2012; Wasonga et al., 2017).

Climate change also leads to the increased prevalence of water level fluctuations and droughts; for instance, Lake Bangweulu Complex fishery in Zambia has been gradually drying up over the last few decades (N'gonga et al., 2019). The average depth of the lake decreased by 0.66 metres between 1974 and 2011, and the relationship between that period and the water level is a threat to limnological processes (N'gonga et al., 2019).

Humanity must adapt through a process of planned adjustment that can safeguard against escalating risks (IPCC, 2007). Examining how the paradigm of climate change adaptation functions as a discourse of knowledge, structures of power, and institutional practices that together produce specific ways of thinking about processes of social and ecological change is essential for sustainability. Given the nature of inland fisheries characterised by multi-gear and multispecies diversity, climate change effects will vary, even though the potential impacts are mostly understudied. Small-scale inland fisheries are likely to be affected by climate change, with dire consequences on the livelihoods they sustain. Current

climatic trends in Southern Africa show that air temperature is likely to increase between 1-3 °C by 2080, while mean rainfall is expected to increase and decrease respectively. (Muringai, et al., 2020). The frequency and intensity of El Niño events are anticipated to increase, leading to extreme weather patterns with more episodes of flooding and droughts. The frequency and intensity of cyclones are expected to increase, with serious implications, mainly for states that are in the south-east of the SADC region (Reid, 2016).

These climatic changes will have negative ecological, socio-economic and institutional effects on freshwater fisheries. For instance, the limnological processes of inland fisheries will be altered, affecting primary productivity, growth, and reproduction (Muringai et al., 2020), events which have been observed in several fishery areas such as the Lake Tanganyika where the intensity of stratification has altered primary production and caused declines in fish catches, with cascading impacts on livelihoods and food security. According to Ndhlove et al. (2017), the obvious impacts of climate change may include severe weather patterns, such as floods and storms, leading to loss of fishing gears and destruction of post-harvest structures, and several other consequences that cannot be entirely detected or foreseen (Figure 2.1).

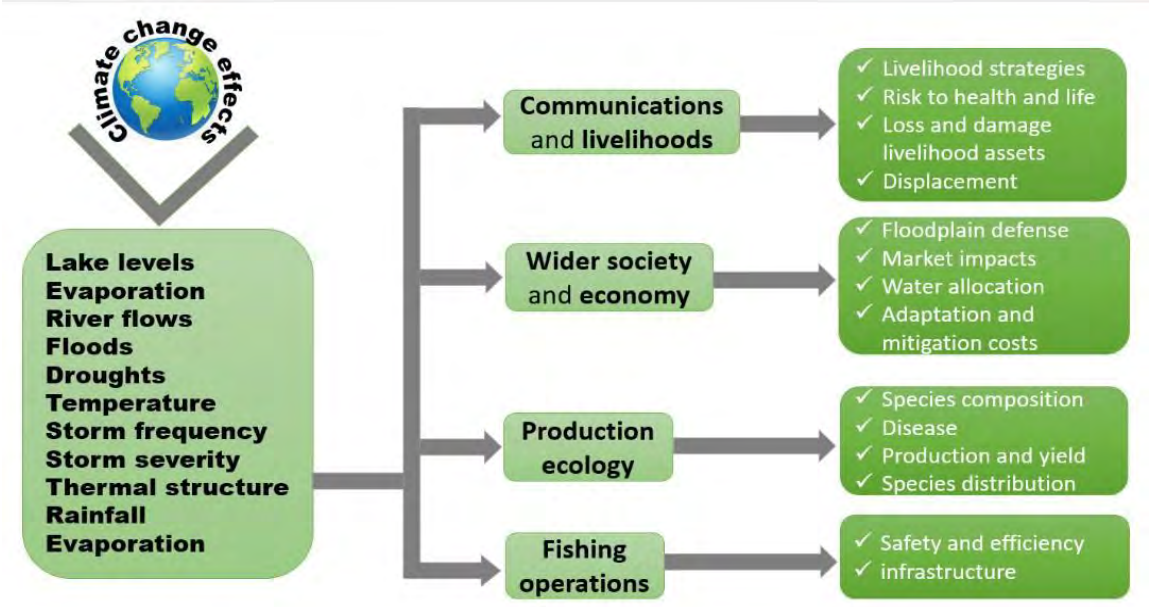

Figure 2.1 Multiple effects of climate change on inland fisheries

Adapted from FAO (2022)

Climatic change will have direct impacts on the availability of food from the aquatic environment because of changes in the ecological niches, and the distribution of fish species (FAO, 2022). The stability of resources will be affected because of variations in the seasonality and rapid changes in the manner through which the ecosystem functions (Barange & Perry, 2009).

Specific interventions will be necessary to build resilience against climate change effects in the inland fisheries sectors; such interventions should aim at equipping fisher communities with skills and knowledge that are attuned to local environment context and specifics. The Paris Climate Agreement of 2015 acknowledges the urgent need for progressive responses to the massive threats posed by climate change, using local intervention and adaptation strategies.

2.4 Concepts and Theories used in Fisheries Management

2.4.1 Fish Decline and Over-fishing

The extinction or changes in the abundance of an individual fish species is an indication of over-fishing, among other factors. Extinction occurs when a particular fish stock has gone extinct, even if overall fish production has not shown a significant decrease, as in the case of Lake Kariba (Kolding et al., 2003; Allan et al., 2005). Declining fish stock is a serious issue and is the most common challenge facing fishing communities in many fishery areas (Tickner et al., 2020). The Chambo fish species have declined in Malawi (Hara, 2011), and fish stocks have also declined in East Africa's Lake Victoria (Ogello et al., 2013).

The archaeological written research has several examples of ancient human fishing associated with slow shifts, through time scale lines to smaller sizes and serial depletion of species that we can now see as symptoms of the over-exploitation of fisheries resources (Jackson et al., 2001). Several factors are attributed to the cause of overfishing, including exogenous and endogenous factors of overfishing in small-scale fisheries. Exogenous factors include market conditions, while endogenous factors are pressures over fish resources that affect fish catch (Cinner & McClanahan, 2006).

To understand the socio-ecological properties and dynamics of small-scale fisheries, Pauly (1997) introduced the concept of Malthusian overfishing which is the increasing number of fishers due to new entrants who choose to do fishing because of a lack of assets. Malthusian overfishing is a narrative of what happens when these new fishers, who lack the land-based livelihood of traditional fishers (e.g., a small plot of land or seasonal work on nearby farms or plantations), are faced with declining fish catches and who then intensify resource destruction in order to meet their immediate needs (Pauly, 1997). According to the Malthusian theory, overfishing occurs when the fish resources reach the limit of their ability to reproduce naturally,

accompanied by the increasing number of fishers who must continue fishing in the face of declining fish catches. Fisheries resources have not been well managed, if they have been managed at all (Berkes, 2001; Andrew at al., 2007). Bailey and Jentoft (1990) contend that, in many cases, "lack of success in the development of fisheries can be traced to a lack of understanding and respect for socioeconomic and cultural characteristics of the target populations".

The failure occurs when resource users are completely anonymous, and lack a solid ground of trust and reciprocity, cannot communicate, and have no traditional norms (Basurto & Ostrom, 2009). The powers to govern and access common pool resources is vested in user groups by collective ownership or through customary tenure (Feeny et al., 1990; Sandstrom, 2008). Unfortunately, these common pool resources have been mistakenly regarded as open access, a condition that leads to overfishing of fish resources, and the phenomenon rooted in the concept of the 'tragedy of the commons' developed by Hardin (1968).This is a best-fit example of Lake Kariba that has been mistakenly considered as an open access over time

2.4.2 The Tragedy of the Commons Model

Hardin's *Tragedy of the Commons* is often cited as the most useful paradigm in the management of resources held in common, including fisheries. Hardin's theory contends that unregulated access to common property resources, such as open sea fisheries, leads to unchecked exploitation and environmental degradation (Hardin, 1968). The model suggests that all resources used as common pool are bound to over-exploitation and will eventually decline. Hardin's ideologies strongly suggested that the 'tragedy of the commons' concept applies in its broader sense to a universal environmental challenge. Tragedy is triggered when each individual is locked in a space that coerces him or her to increase his herd without limits, in a space that is limited. Ruin is the destination towards which all individuals rush, each pursuing

their own interest within a community that believes in the freedom of the commons (Hardin, 1968). This suggests a serious social dilemma involving an individual's rational conduct where the absence of restraint in maximising personal short-term gain can cause long-range harm to the environment, other individuals and ultimately, oneself (Ostrom, 1990; De Young & Kaplan, 2012). It becomes difficult to observe the fisher incentives of improved fish catches, as opposed to harvesting as much as possible, since resources like fish are fugitive and the fish you do not catch today may be caught by someone else in the future (Ostrom, 1990; Berkes et al., 2001).

At the individual level, if open access and overfishing causes demand to exceed supply and keeps prices high, despite declining catches, fishers may not see the benefit of sustaining the resource unless the long-term damage is highlighted to them (McConney et al., 2003). Hardin ignored the costs imposed on others. Such individual rational decisions accumulate and result in a socially irrational outcome. Hardin prescribed that to prevent this 'tragedy', common property resources should be 'privatised'. This ideology has received a wide global criticism particularly among the scientific community, largely because of its simplistic approach towards conservation (Basurto & Ostrom, 2009)**.** However, over time, there has been isolated discontent in striving for simple answers to solve complex environmental problems, and a desire to move beyond panaceas to build a solid field of sustainability because problems of over-harvesting and the misuse of ecological systems are rarely attributable to a single cause (Ostrom, 2007; Olsson et al., 2008; Bennett et al., 2017).

The common-property theory and debate has not been confined to the academic arena, but has had a wider sweeping implication in policy reforms (Aswani, 1997). This move has largely inspired several researchers and resource practitioners to a strong belief that restraining freedom of accessibility and operation in a given fishery is the best option for sustainable resource management and poverty alleviation in fishing-dependent communities around the world, an assertion that has granted Hardin's theory the high-profile status of divine

intervention in the management of natural resources (Aswani, 1997; Agello et al., 2013). However, this prescription serves a top-down management system requiring external actors and the forces of law to protect the rights of the private entities to managing the commons as deemed fit. Over a long time, Hardin's theory has remained the foundation for sustainable management of common pool resources all over the world (Ostrom & Cox, 2010).

2.4.3 Critique of Hardin's theory

Despite its dominance in literature, Hardin's theory has been widely and deeply criticised by a range of experts (Feeny et al., 1990; Berkes et al., 2001). It overlooked social relations and several other cultural aspects that would influence natural resource users to congregate after many years of experiencing declining resources and find possible interventions to regulate the conditions leading to decline and agree upon a set of rules of conduct that would effectively limit over-exploitation (Donda, 2000; Berkes et al., 2001; De Young & Kaplan, 2012). Community resource users in which natural resource extraction is done are often guided by social-cultural values and norms, which are mostly non-contractual, some of which place emphasis on moderation and prudence. Practically, these principles subject individual fishers to social pressure which regulates their conduct (Berkes et al., 2001).

Hardin's metaphor confused 'common property' with 'open access'. According to Ciriacy-Wantrup and Bishop (1975), common property resources basically refer to "a distribution of property rights in resources where several ownerships are co-equal in their right to utilise the resource." There is a whole class of natural resources for which exclusion is quite difficult. Any efforts to solve the tragedy of the commons makes it necessary to know the property rights regime in operation and implications of each. Ostrom (2000) subdivides property rights into use rights (defining the right of access to a defined physical area) and control rights (defining the right to manage a resource). When property rights are established, well defined, and clear enough to all stakeholders, common action is attainable. There are four

ideal analytical types of property rights: state, private, communal, and open access. If access to a resource is not controlled, as in open access, sooner or later the resource will be subject to the 'tragedy of the commons'. Lake Kariba, like most of the inland fisheries in the third-world countries, exists as an open access fishery, theoretically under contemporary government management and/or under local (traditional) chiefs within some form of common property regime (Andrew et al., 2007).

Where rights exist, the conditions under which collective responsibilities are made and adhered to will be major determinants of success, characterised by national territorial partitions where all individual fishers have liberties and freedom to fish (Andrew et al., 2007). Fish stocks of Lake Kariba have shown symptoms of overfishing through extinction of certain fish species (Kolding et al., 2003; Tweddle et al., 2015), with some fish species, like *Tilapia rendalli* and *Oreochromis motimeri,* designated as either endangered, threatened, or vulnerable (IUCN, 2010). Hardin's predictions for the inevitable over-exploitation of a commons were mostly based on consideration of open access conditions. Over time, a number of researchers have come up with new explanations suggesting that certain fundamental conditions must be met before a tragedy can occur; a situation where restraining access to the resource is costly, impractical or impossible (Berkes et al., 2001).

More often, tragedies occur when an open access system takes over a pre-existing successful common property (common pool) resource (CPR) management system (De Young & Kaplan, 2012). Furthermore, aspects of cultural and institutional arrangement in Hardin's theory are missing, which should be integrated for more detailed prediction and analytical resource use (Feeny et al., 1990); the tragedy of the commons may be triggered only if natural resource users become greedy by pursuing personal interest against the interest of the majority of the community members.

Despite having a wide criticism in literature, Hardin's theory regarding common property resources utilisation is a very important model for analytical work in natural resources conservation, including fisheries (Berkes, 1985; Feeny et al., 1990). In a social and ecological system like fisheries, the commons paradigm may happen when fishers realise that fishing activities in a given fishery are more profitable, leading to fisher migration to maximize fishing, and thereby increasing fishing effort. When catch per unit effort increases beyond the ability of the fish to replenish, fish regeneration problems occur and cascade into overfishing and fish depletion, with consequences on livelihoods (Allan et al., 2005; Irvine et al., 2019). Despite the common paradigm shaping trends in management of natural resource held in common, fish resource decline has been widely recognised in developing countries, a trend that endangers the livelihoods and dietary security of its dependent communities. It is therefore not correct to design or prescribe management interventions based on assumptions of a specific model to be a universal characteristic of a socio-ecological system, but rather of an essential type of system with broadly relevant but precise attributes (Ostrom, 2007).

In recent decades, several other management approaches have emerged, including collaborative approaches and resource-user participation in decision-making processes, community-based fisheries management and co-management (Berkes et al., 2001; McClanahan et al., 2009). Other approaches include an incentive-based management system which stipulates territorial rights of groups and individuals (McClanahan et al., 2009; Hara & Njaya, 2016). The idea of community participation in fisheries resource management has been widely documented in literature (Kapembwa et al., 2021). However, this idea has not been well enshrined in policies and resource management by governments (Haambiya et al., 2015) which, as a result, have largely failed to comprehensively accommodate resource users, a situation that has led to resource depletion and user conflicts (Pomeroy, 1995). Based on the above narrative, active community participation must be applied through legal and institutional framework at

all levels of governance (Pomeroy, 1995). Several aspects that can contribute to the successful implementation of fisheries co-management have been highlighted by Pomeroy (1995); for instance, a community-based fisheries management approach has been in existence around the globe for a very long time. However, the key issues with regard to community participation in developing countries are not well documented, including information with regard to their role and functions, and data on socio-economic conditions (Ruddle, 1994). Andrew and Evans (2009) established three forms of management frameworks for small-scale fisheries. These include an ecosystem approach to fisheries (EAF), a stakeholder's rights-based approach, and Ostrom's framework for social and ecological analysis. Such a combination of frameworks can greatly improve the management of inland small-scale fisheries in Lake Kariba

The ecosystem-based approach recognises the physical, biological, and socio-economic interactions in a social and ecological system to meet a set of societal goals (Marasco et al., 2007), and it considers knowledge about the interface among the biotic, abiotic, and human aspects of an ecosystem and their interactions to build up an integrated system to fisheries management (FAO, 2003).

2.4.4 Ostrom's Socioecological System

To appreciate factors affecting freshwater fisheries, Ostrom's framework provides a common framework for researchers in different fields to share and compile their findings to broaden the understanding of complexities that shape human-environmental linkages in a social and ecological systems (Ostrom, 2009). Ostrom's framework acknowledges the complexity of designing a diagnostic way to identify combinations of variables that affect the incentives and actions of users under different governance systems. In this study, the framework describes a multitude of features which influence social and ecological systems (Ostrom, 2009). It addresses the creation of institutional conditions under which governance and management of

common-pool resources can be accomplished through a well-managed collective action of governance processes. The framework provides for a multiplicity of various socioeconomic and governance layers within the socio-ecological system (SES) to analyse the sustainability challenges of a given resource (Ostrom, 2007).

The application of Ostrom's social and ecological framework to understand social and ecological systems can enable researchers to classify cumulative and coherent, empirically supported answers to common patterns of interactions and outcomes, such as over-exploitation, conflict, collapse, stability, and increasing returns from using a particular set of rules for the governance (Ostrom, 2007). In the case of Lake Kariba, the framework can further be used to detect endogenous development of different governance arrangements, use patterns, and outcomes, with or without external financial inducements.

2.5 Chapter Summary

This chapter reviews the socio-economic importance of small-scale inland fisheries and the challenges associated with management aspect the resource. The value attached to small-scale inland fisheries prompted a discussion within the context of which various theoretical frameworks have been briefly outlined for analytical work and as a guiding tool for the study. Based on the recent available empirical data, we discussed the potential and value of small-scale fisheries for employment, food security and biodiversity conservation. We also demonstrated that, given the value of the small-scale fisheries in the region, there are growing concerns regarding the management aspects that may have a negative impact on the utilisation of the fisheries resource.

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Chapter 3: Methodology

Chapter 3 of this study presents the philosophical research paradigm which systematically guided the sampling design, sampling procedure data collection methods, and analyses. It provides a brief description of the Lake Kariba fishery in Zambia, where the study was conducted. The chapter concludes with the context and a brief historical background of the study area. Figure 3.1 summarises the methodological framework of the study. The methods used are further highlighted in the published Chapters 4 and 5 of this study.

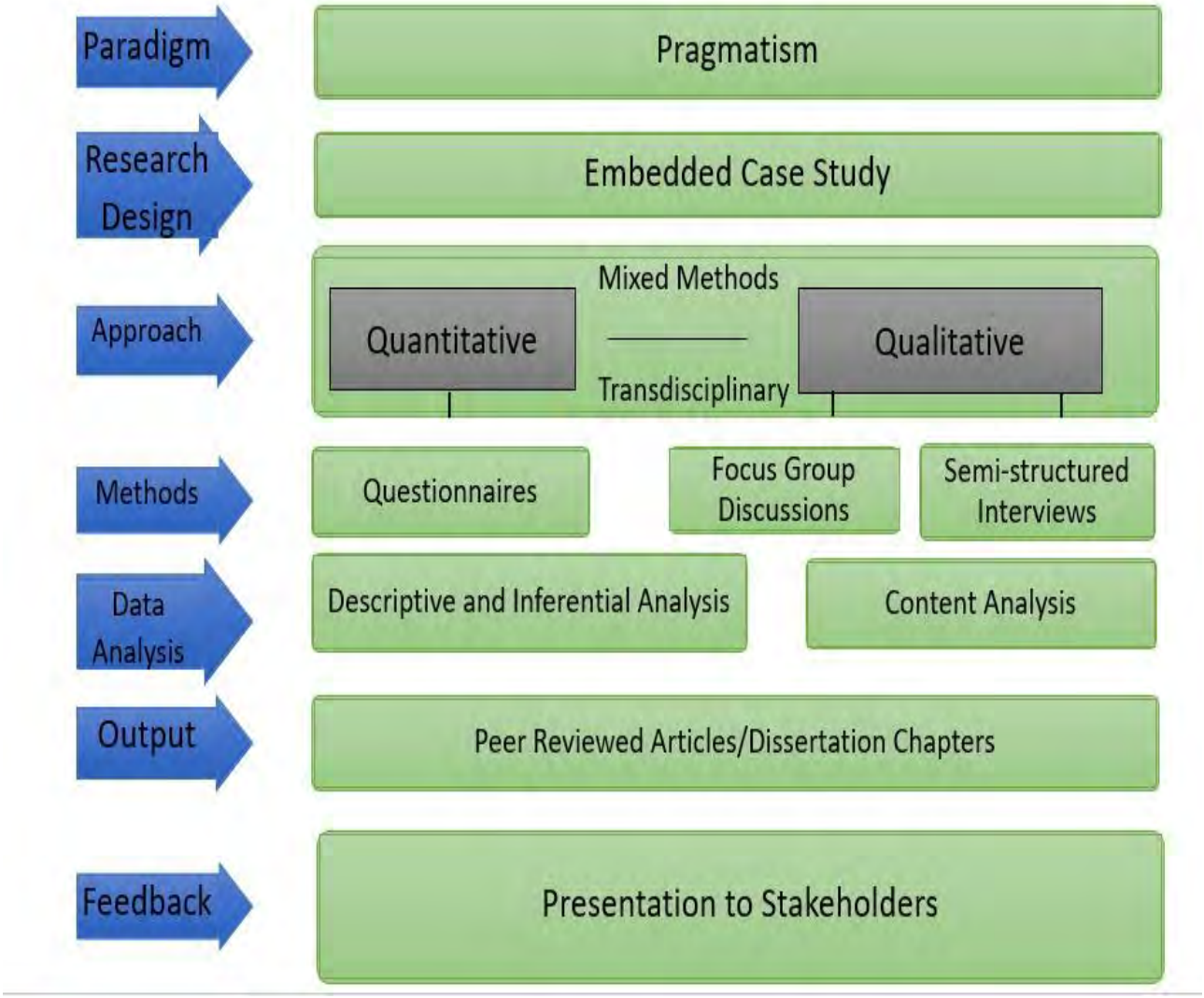

Figure 3.1 Methodological framework guiding the research design

3.1 Pragmatic Approach

This study is guided by the pragmatic paradigm, which plays a pivotal role where multiple studies are carried out in phases. The approach is widely recognised in research involving social science studies (Creswell, 2014), because it does not focus on only a single system of reality and philosophy, but uses multiple techniques and procedures that are suitable to meet the objectives and purposes of the study (Creswell, 2014; Burke & Christensen, 2014). This study, therefore, applied a mixed-methods approach to obtain data from both qualitative and quantitative assumptions (Creswell, 2014), so providing a more detailed understanding of the research problem and helping to determine other factors that may have an impact on the topic of study (Morgan, 2007). The approach increases the understanding of critical aspects of livelihood strategies and social organisation at community level (Walsham, 2006).

3.2 Description of the Study Site

The middle-Zambezi valley, where the Lake Kariba fishery now lies, is a man-made lake (artificial) which emerged following the construction of a dam wall on the Zambezi River for the purposes of hydro-electric power (HEP) in 1958 (Mhlanga, 2009). The lake is located along the international boundary separating Zambia in the north and Zimbabwe in the south. It lies between latitudes 16°28′ and 18°06′ south, and longitude 26°40′ and 29°03′ east. The Lake Kariba catchment is one of the primary areas of wilderness and protected areas on the main land and on the island which has created an interface of interaction between human and wild animals (Ndhlovu et al., 2017). The two riparian countries, Zambia and Zimbabwe, now share the Lake in the ratio of 45 to 55, respectively (Ndhlovu et al., 2017). In accordance with the principles of Bazigos (1974), Lake Kariba Fishery on the Zambian side is divided into four different ecological strata falling into the three political districts of Sinazongwe, Gweembe and Siavonga. Each of these districts has a specific collection number of fishing villages ruled by

a traditional leader (Chief) (FAO, 2007). These strata are geographical units and form the basis for statistical data collection (Bazigos, 1974).

The Lake stretches about 280 km in an east-west direction and covers a surface area of 5577 km^2. Two distinct types of fisheries, including the Kapenta fishery, operate from semi-industrial rigs offshore and catch only *Limnothrissa miodon,* locally known as Kapenta. The second fishery is an inshore, artisanal fishery which is low-cost, non-mechanised and catches multiple species (Kolding et al., 2003; Overå, 2003). However, what appears to be another fishery, is the rapid development of inland aquaculture using commercial fish cages; this innovation is growing rapidly and changing the face of the fishery. It houses some of the biggest fish farms in Africa (FAO, 2022; FAO, 2023).

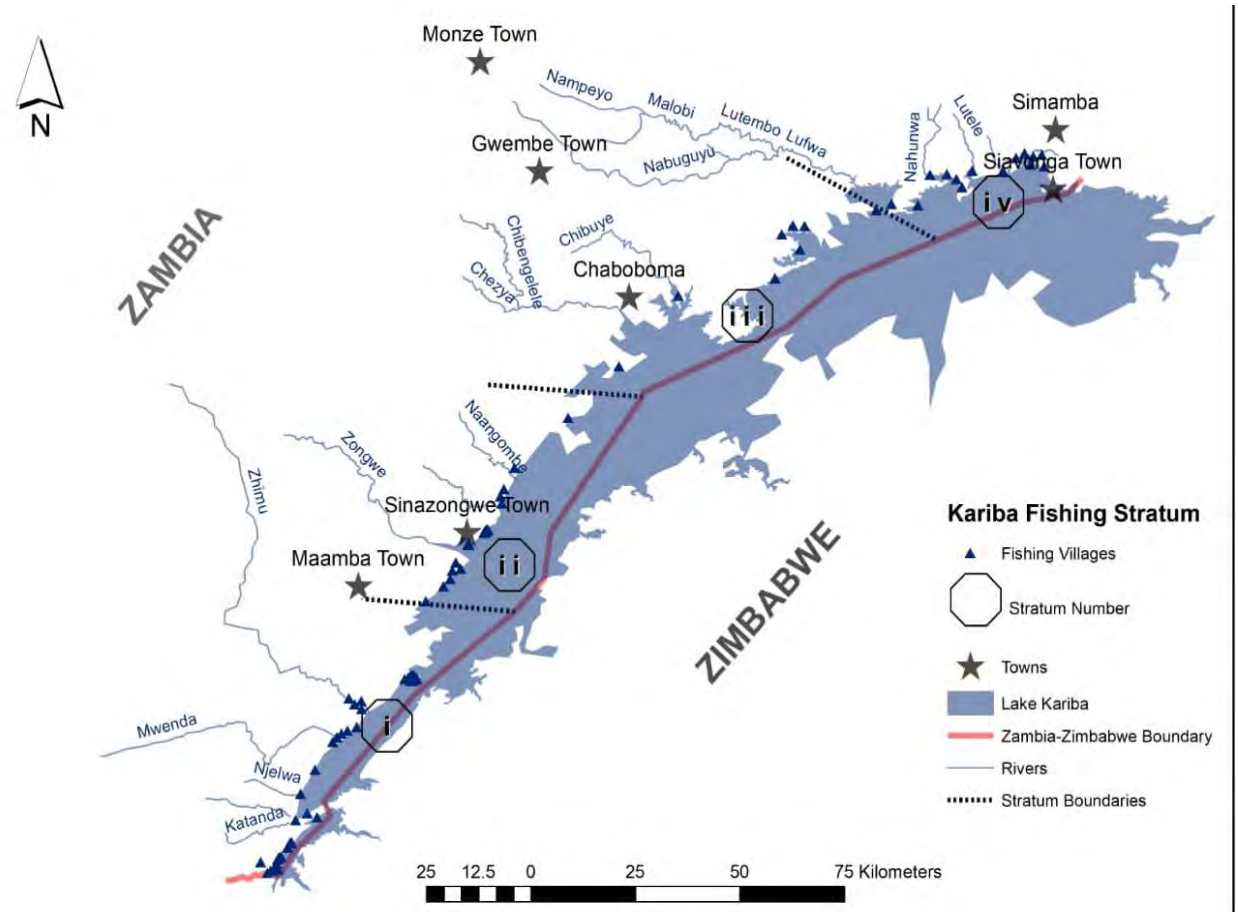

Figure 4.1 Map of Lake Kariba fishery indicating geographical strata and dotted fishing villages

3.3 Basis for Choosing the Study Area

Lake Kariba was selected as a study area because of the 10 years I spent in the area designing fisheries research activities and carrying out extension work with fishing communities. This experience exposed me to many of the gaps in managing a socio-ecological system that has evolved anthropogenically in time and space, before and after the damming of the Zambezi River. This transition brought about substantial socio-economic and environmental changes that have had a negative impact on livelihoods of vulnerable communities to date (Mhlanga, 2009). The area around the lake is inhabited mostly by victims of displacement who were forcibly moved to inhospitable, dry, semi-arid land areas following the construction of the dam wall across the Zambezi River. The area where they used to practise floodplain crop agriculture was inundated by water, thereby restricting them to dryland farming (Scudder, 1975). These socio-ecological conditions make Lake Kariba ideal for this study.

The complementary indigenous systems of cash flows between farming and fishing, where income generated from fisheries was used to purchase agricultural inputs, and food from crop agriculture supported fisher communities was disrupted. Local ecological knowledge which was founded on the Zambezi River habitat, was no longer very useful in inland areas. Land-use changes led to the deprivation of their ecosystem services, altered the cultural values, and contributed to the loss of indigenous knowledge systems of managing property held in common since the government took over without considering community participation in resource management. This adversity in land use change and forced relocation inspired me to conduct a study to document some of the challenges which affect management of the Lake and examine whether novel systems of community/common property systems developed post-1958. The socio-economic and ecological characteristics of the region are in line with my area of study, making the site an ideal candidate for the topical study.

3.4 Socioeconomic Characteristics of the Study Area

The riparian communities along the shores of Lake Kariba are highly scattered due to the forced displacement during the construction of the dam that formed the lake (Mhlanga, 2009). This development led to a transitional change in the land-use governance of a large terrestrial ecosystem along the lakeshore area, therefore demographic information about the fishing communities' populations keeps changing due to fisher migration. However, the FAO (2019), claims that Lake Kariba is among the most productive fishery in Southern Africa, having 50 different fish species (Kolding et al., 2003). It contributes more than 90% of Zimbabwe's fish production (FAO, 2019), and ranks among the highest fish producer on the Zambian side (Genschick et al., 2017). Most of the people in Lake Kariba are directly or indirectly involved in fisheries as their main livelihood, as a part-time activity, or as a form of employment (Ndhlovu et al., 2017). Gillnet fishing is one of the oldest fishing methods dating back to the Neolithic period (Mendonca & Pereira, 2014). Gillnet fishing entails the use of nets to trap or catch fish, therefore, it is regarded as the lowest-cost fishing method (Mendonca & Pereira, 2014). Tourism activities based on water sports, wildlife resources and hospitality also play a significant role in creating employment for the local communities (Ndhlovu et al., 2017)

3.5 Sampling Design

Zambia was purposively selected for the study owing to the lack of adequate social-economic data to support management decisions for the fishery (Kolding et al., 2003; Nyikahadzoi et al., 2017). The Zambian waterfront is shared by three administrative districts, and all of them were considered for sampling during the study. The entire shoreline, including the three districts, comprises 65 fishing villages (LKFRS, 2011), which are stratified into four geographical strata coded as I, II, III and IV. This stratification is used for the purposes of statistical data collection (Bazigos, 1974). A reconnaissance survey was initially undertaken in

October 2020 before the actual data collection began to verify the sampling frame, focusing on strata and the demographic features of the fishery (Yuerlita, 2013).

The reconnaissance survey helped to factor in possible adjustments to the sampling frames and procedures since the population dynamics in fishing communities are constantly changing in response to various economic pressures, that often result in fisher migration. As such, a proportional quota sampling technique was used to select a more representative sample size. This was carried out with the help of secretariat to the fishing village management committee in every sampled fishing village. The sampling frame for fishing villages was based on the 2011 frame survey report which was the best available information during the study (FAO, 1995; FAO, 2005). The existence of these fishing villages was subjected to further verification with the help of fisheries extension officers from the Department of Fisheries (DOF) in the area of study. Proportional quota sampling in this context was useful as it allowed the researcher to identify general categories or clusters into which participants could be placed to select a predetermined number of participants for every stratum (Neuman, 2014).

Proportional quota sampling also enabled the researcher to have a sample size in each stratum which was directly proportional to the number of participants in a targeted population (Bernard, 2011). This technique was more appropriate in this context because all the fishing villages along the shoreline of Lake Kariba are purposefully categorised into strata, for statistical data collection (Bazigos, 1974), which helped to validate the reliability of the study since the focus was on an individual stratum. (LKFRS, 2011). Precautions were taken to ensure that all the fishers where data was collected were living within the fishing village of a particular stratum. To obtain this, a snowball sampling technique was used to identify fishers who were actively involved in fishing: each respondent was asked to identify other possible respondents through social linkages (Bernard, 2011). The snowball sampling technique was useful in identifying more appropriate respondents from every selected fishing village since it enabled

an individual respondent to choose responsible participants (Bernard, 2011). According to the frame survey report, the estimated fisher population around Lake Kariba fishery was approximately 2,240 (LKFRS, 2011), and based on this number, a sample size of 300 participants was drawn at 95% confidence level (see details in published Chapter 5 of the study). To obtain a good representative sample size, the study sampled 20 out of the 65 fishing villages in which data was collected, meaning that 30% of the total number of fishing villages gave a 95%, confidence level, (Burgess, 1982). These fishing villages were purposefully selected during the scoping stage because of the haterogeneous nature of fishing communities and the observed high fishing activity rate as compared to the rest of the fishing villages. More details on sampling design are highlighted in published Chapters 4 and 5 of this study.

3.6 Data Collection Methods

This study used multiple data-collection tools in order to achieve a detailed understanding of the topic of study and data authentication (Heale & Forbes, 2013; Carter et al., 2014). Both qualitative and quantitative methods were employed; qualitative methods included Focus Group Discussions (FGDs) and in-depth interviews with key informants (see Appendix B). In addition, direct participant observations and the desktop study of literature (Published journal articles, government gazettes, books and grey literature) were used. The quantitative approach comprised a semi- structured household questionnaire survey.

3.6.1 Household Survey Questionnaires

A household survey questionnaire was employed to collect data using pre-tested semi-structured questionnaires, composed of qualitative and quantitative techniques, as a more practical instrument, particularly in examining livelihood strategies, occupation and adaptation strategies as suggested from previous studies (Ellis & Freeman, 2004). Semi-structured interviews help to obtain primary information used for describing a larger population and use

standardised questionnaires to collect essential data for analytical work and interpretation (Babbie & Mouton, 2001; Kothari, 2004). 'Household' in this context is defined as an entity made up of individuals who dwell in the same area and share common goods and services (UNDP, 1996; Austin, 2005). The questions were developed in English as the official language of Zambia and translated into Tonga, the local language. The mixed household questionnaire was phrased with different questions to obtain many more responses for different parts that were linked to every research question and objective of the study (Appendix A). The types of research questions included demographic characteristics such as respondent's biography (Babbie & Mouton, 2001). Some of the questions in the questionnaire were open-ended and designed to capture more ethnographic details on the topic of study, including basic details on how the household survey questionnaires were administered to obtain specific information.

The snowball sampling technique was proved useful in every sampled fishing village to choose adult respondents (fishers ≥ 20 years of age). Although this technique may have some levels of bias, it was more appropriate in this context because some of the most prominent fishermen were absent during the survey. Those fishers who were present during the survey were identified by their colleagues, particularly in the fishing villages. In this context, the sampled fishers in every fishing village were cordially requested to identify other active fishers (Alvi, 2016). The household survey employed three research assistants who helped to administer the questionnaires following a successful training that concluded with pre-testing the questions on a different population.

3.6.2 Focus Group Discussions (FGDs).

Most of the topics under discussion through focus groups were, to a large extent, similar to those in the household survey questionnaires, but were discussed in detail, using the fishing community as a measure of analysis. Participants in focus group discussions were purposively

selected based on their knowledge and experience regarding fishing activities over time. The discussion began with a short presentation about the overall objective of the study. Participants were encouraged to express their ideas freely, describing their experiences and giving their opinions with about pertinent issues, including the economic importance of the fishery resource for local livelihood, the condition of the fishery, the changes observed by various stakeholders, and the reasons behind such changes (Bless et al., 2013; Appendix 2). For the sake of transparency and divergent views, FGDs comprised fishers, traders, transporters, traditional leaders, and fish processors. This technique of gathering data ensured the validity and reliability of data (Creswell, 2014). Observations and summary note taking were used to collect data. Detailed information on the composition on the usage of focus group discussions are further highlighted in Chapter 5 of this thesis.

3.6.3 Semi-structured Interviews with Key Informants

Semi-structured interviews with key informants were used to obtain detailed information about the condition of fishery resources and fishing activities. The key informants were chosen based on their past experiences and vast knowledge, ideas and experience on the subject. In this regard, the snowball sampling technique was very useful in identifying key informants, because it involved a strategy where each key informant was requested to choose other possible informants through networks of interaction. Interview schedules with some of the key informants of different backgrounds consisted of structured questions involving multiple primary questions intended to define areas for investigation (Britten, 1995). More details on key informants and data collected are shown in Table 3.1

Table 3.1 Key informants and data collected.

Key informants	Information
Traditional leaders	Community participation in fisheries
Experienced fishers	Trend of fishing activities
Fisheries officers	Fisheries resource and fishing activities
Local government officer	Land-use system
Agriculture officers	Agricultural practices
Civil society organizations	Livelihood strategies
Environmental officers	Environmental condition of the fishery
Fish traders and processors	Marketing and post-harvest activities

The key informant interviews were useful to explain details and confirm earlier information obtained from fishers through the FGDs and survey questionnaires. This technique was also useful in validating the reliability of information collected during the study (Ghosh, 1992; Creswell, 2014).

3.6.4 Field Observations

Field observation is a useful data collection method to appreciate the environmental issues in the area of study. The researcher was able to obtain data on routine activities of men and women, what goes around, who is involved (Jorgensen, 1989). In addition, note-taking during field observation and other observed situations was very important to support the key informant interviews. Field observation undertaken during the study covered various livelihood activities, including post-harvest activities, fishing, crop agriculture and the people who are involved in these activities. Cultivation practices along the shoreline, fisheries activities, waste management and the sewage system surrounding the fishery were observed. Further observations showed the kind of fishing methods and gear used.

3.6.5 Secondary Data

Relevant sources of secondary data were selected by applying a content analysis technique, a process whereby relevant literature was put in various categories for easy searching. Secondary data sources included published journal articles, government reports such as case studies, socio-economic, biophysical, physical and project reports. Published journal articles were obtained from the internet web (Google Scholar) and FAO country profiles website (see details in Chapter 4 of the study). Fish catch data, such as production figures and price fluctuations, were collected from fish traders and the Department of Fisheries for the purposes of triangulation and to provide a detailed understanding of the existing status of the fisheries resource. This information was useful for cross-checking and verifying primary data. The information was also used to analyse total fish production over time.

3.7 Data Analysis

Data collected using the questionnaire survey was scrutinised for outliers and entered into the Excel computer application through coding of different variables. Descriptive statistical tables and graphs were generated on major threats to fisheries biodiversity and other aspects of livelihood adaptation strategies. Since the study used a mixed-method approach to obtain different categories of data sets, both quantitative and qualitative data were analysed (Acaps, 2012). Analysis of qualitative data (the key informant interviews and focus group discussions) (Bryman, 2001; Acaps, 2012) was carried out using a theme-based content analysis technique which involves a "process of scrutinizing all the interviews to identify similarities and validate inferences from data with the view of generating new knowledge, ideas and as a guide to action" (Krippendorff, 2004). The analysis of this data was described with statistical information, tables and graphs from quantitative analysis. The method was useful for exploring the condition of the fishery area and its environment, together with the respondents' opinions on the condition of the fisheries resources.

The analysis of quantitative data obtained through household questionnaire surveys was carried out using R statistical software version 3,9.1, 2020 and using bivariate statistics for a more detailed understanding of fishing effort indicators over time. The fishing effort indicators identified during the study included the increase in the numbers of fishing boats, fishing gears and fishers over time. As such, the chi-square (Pearson's $\chi 2$) test was useful in analysing the dynamics of fishing effort indicators over time. Details of this analysis are highlighted in the published Chapter 5 of this study.

Fish production trends in the past 13 years were analysed using a curve fitting estimation regression test. This test has been widely recognised and is used to interpret time series data; it provides the best fit for specific curves in the dataset for trend analysis over time (Setia, 2017). To verify data reliability, the study employed different data sources, an approach known as triangulation which enhances the trustworthiness of the data (Bless et al., 2013). Reliability "is a degree of accuracy and consistency of an instrument", while validity is "the level to which research measures what ought to be measured" (Bless et al., 2013:395). The idea of triangulation implies that "multiple data collection methods and modes of data analysis are accurate on facts" (Kohn 1997:7); in this context, data were drawn from different participants with divergent views using FGDs, interviews and surveys, to depict triangulation. The questions asked in all the data collection instruments were consistent and designed to address the research objectives and questions.

3.8 Ethical Issues

Ethical consideration is a very important measure to validate the legitimacy of a study and to guide the appropriate way to undertake research. The ethical issues define what constitutes a sound research procedure for both animal and human ethics (Neuman, 2014). This study was reviewed and approved by the Rhodes University Human Ethics Committee (RU-

HEC). number 2020-1571-4696 prior to data collection. Once the study was approved, data collection was carried out in line with acceptable principles and international standard ethical guidelines (see further details in the published paper, Chapter 5). The study safeguarded against any possible risk that would have negatively affected any participants involved in the study, in line with the policy for responsible research conduct at Rhodes University.

Permission to proceed with data collection was further sought in writing and was granted by the Directorate for the Department of Fisheries, Zambia. The subject of the study was part of a larger African Development Bank-funded project known as the Zambia Aquaculture Enterprise Development Project (ZAEDP) whose overall aim is to facilitate sustainable fisheries and aquaculture development along the Agro-fisheries value chain in an attempt to promote food and nutritional security and employment for rural livelihoods.

3.9 Study Context and Historical Background of Lake Kariba Fishery

Although Zambia is a landlocked country, it is richly endowed with an estimated 40% of the total surface water in Southern Africa (ZDA, 2011). The abundant water resources in Zambia are derived from three major basins: the Zambezi, Luapula and Congo basins. This abundance has created a strong foundation for active commercial and artisanal fishing activities in various natural water bodies, including Lake Kariba. To comprehend the environmental and socio-economic conditions of the Lake Kariba fishery and its impact on livelihoods, it is imperative to investigate the development perspective of the fishery in time and space because these developments led to a wide range of socio-economic and environmental changes that have transformed the tenure systems and subsequently led to broad environmental changes that are a threat to conservation and livelihoods (Mhlanga, 2009). This narrative is not a problem statement, but the development of the fishery is important since the lake is an artificial one that can be described in time and space (Kolding et al., 2003). The lake was created by the

construction of a dam wall across the Zambezi River in 1958 (Mhlanga, 2009). The need for increased hydroelectric power to boost industrial activities in the then Northern and Southern Rhodesia, now known as Zambia and Zimbabwe, necessitated the damming of the Zambezi River in 1958.

This innovation brought many new opportunities, such as tourism, fishing (both artisanal and semi-industrial) for the newly introduced freshwater sardine (*Limnothrissa miodon*), and wildlife sanctuaries on both sides of the lake. New institutions and other authorities engaged in tourism dominated and became some of the key stakeholders as they progressively tapped into the newly established opportunities. Currently, there are several private entities supporting diverse economic activities on the lake, including wildlife and tourism. The recent development of large-scale inland aquaculture exacerbates the pressure of competing claims over fishing grounds with the introduction of land-based aquaculture facilities that further escalates environmental concerns. It is within this context that we entitled this study "Assessing the vulnerability of inland Fisheries to Human-Induced Perturbation with

Lake Kariba as a Case Study". Previously, the indigenous people had chiefly depended on the whole lacustrine freshwater ecosystem, but they now face user competition and wider environmental degradation brought about by various users operating in the fishery. These local communities were displaced to pave way for the dam construction and have not been able to optimize these new opportunities. Land-use changes and user competition in the fishery have not only altered the socio-economic conditions, but also the indigenous systems of managing the natural resources, thus limiting their participation in conservation of the fisheries resources (Scudder, 1975; Weinrich, 1977). The major problem at the moment seems to be the loss of indigenous socio-institutional arrangements of managing the fishery; central government has prevailed and has not reinstated authority at the local level (Colson, 1962). Livelihoods of local communities are threatened by the intrusion of politically and economically more powerful

resource users. Currently, harvesting of the fishery resource is slowly increasing its economic value. This economic demand has led to local communities being restricted to less productive fishing grounds, thereby reducing their catch rate per unit of effort. The entire fisheries' biodiversity could be under threat as local communities are harvesting fish illegally to maximize the returns, thus leading to what Hardin described as the 'tragedy of the commons.

3.10 Chapter Summary

The chapter presents an overview of the study methodology, including the specific procedures carried out to select, identify the process, and analyse data for the topic of study. In the first instance, the chapter briefly discusses the research design (pragmatic paradigm) that presents a wide philosophy on which the whole study was based. The chapter provides a detailed description of the data sources for the research, sampling techniques and tools that were used during the primary data collection. In addition, the chapter outlines how data was analysed for easier interpretation of the results and narration on the importance of ethics and how they were addressed to carry out the study.

The chapter concludes by outlining a brief historical background of Lake Kariba fishery as an empirical source of data used in the chapters. This chapter gave a very important description of the study area for a detailed understanding of the fishing community in the context of the environment. The chapter which follows is a systematic peer-reviewed paper published as a journal article providing detailed analytical work on the role of institutions, governance and how they affect the utilisation of fisheries resources for food security and biodiversity conservation, particularly in a transboundary fishery resource like Lake Kariba.

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Chapter 4

Results Article I: Transboundary Fisheries Management in Kavango–Zambezi Transfrontier Conservation Area (KAZA-TFCA): Prospects and Dilemmas Sustainability 2023, 15, 4406. https:// doi.org/10.3390/su15054406 [1]

4.1 Abstract

Inland fisheries in the Kavango-Zambezi Transfrontier Conservation Area (KAZA-TFCA) offer food security to the riverine communities across the region. They also contribute towards the attainment of the United Nations' Sustainable Development Goals 1 and 15, which aim to alleviate poverty and maintain biodiversity conservation. Despite this significant role, the fisheries have suffered severe declines in the previous decades due to multiple factors, such as overfishing and poor legislation. Furthermore, climate change is exerting pressure by altering the ecology and productivity of the river systems. The unprecedented challenges of the COVID-19 pandemic have further constrained management efforts. Attempts to address these challenges have pointed towards transboundary fisheries management as a silver bullet in moving towards sustainable fisheries management. However, the implementation of this strategy in the region has encountered numerous roadblocks, thereby subjecting the river ecosystem to a wider environmental threat, with dire consequences for livelihoods. This Chapter reviews

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existing management and governance structures, together with key informant interviews to elicit primary and secondary data essential for management at the regional level. The study identifies conflicting regulations, and inadequate policies and institutions across the region as major bottlenecks affecting the successful implementation of transboundary fisheries management. Finally, the paper offers some suggestions for the improvement of fisheries management in the region.

Keywords: governance; inland fisheries; transboundary; Kavango–Zambezi; CCRF

4.2 Introduction

Inland fisheries in the Kavango–Zambezi Transfrontier Conservation Area (KAZA-TFCA) play a multifaceted role in providing food security, employment opportunities, and a cheap source of protein (Dugan et al., 2006; Lynch et al., 2016; Chan et al., 2021). However, over the last half-century, there have been considerable reports of fish decline and shifts in fish species composition from inland water sources (Kulwijila et al., 2012; Ogutu-Ohwayo & Balirwa, 2004). Studies suggest that the biodiversity crisis is more severe today in inland freshwater ecosystems than terrestrial ones, partly due to overfishing, weak institutions, and habitat degradation (Ogutu-Ohwayo & Balirwa, 2004). These combined and synergistic effects have negatively affected the abundance and range of inland fisheries (Darwall et al., 2008; Ahmed et al., 2013; Irvine et al., 2019). Furthermore, given the acknowledged acceleration of climate change, weather patterns are expected to be more variable and unpredictable, thereby creating stochastic changes that will alter the ecology and ecosystem processes of river systems (IPPCC, 2007; Popova et al., 2016; Ndhlovu et al., 2017). The KAZA-TFCA exemplifies this sustainable challenge (Hackenberg et al., 2022).

The conservation area is drained by the palaeo-evolutionary linked Ka-vango and

Zambezi River systems, which cover five countries, namely Angola, Botswana, Namibia, Zambia, and Zimbabwe (Figure 4.1). Hackenberg et al. (2022) note that the changes in flood patterns over the Zambezi River basin imply that the natural characteristics of these aquatic resources are constantly changing with regard to functional responses of fishes, such as distribution and migration patterns. In addition to these problems, the COVID-19 pandemic constrained management efforts of various countries to engage in timely fisheries management programmes (Belton et al., 2021). Aquaculture has been widely identified as a possible intervention to resuscitate inland fisheries in the region (Mosepele & Kolawole, 2017). However, the prospects of the aquaculture sector are threatened by several factors, such as deterioration of pure brood stock due to the introduction of invasive fish species like *Oreochromis niloticus*, which has the capability to distort native *Oreochromis* fish species through hybridization and predation. Other invasive fish species, such as crayfish (*Cherax quadricarinatus*), may be risk factors (vectors) for the transfer of fish diseases and parasites (Jere et al., 2021). Several studies have revealed that most of the fisheries in the KAZA-TFCA have experienced severe declines in fish catch rates (The WorldFish Center 2007; Tweddle et al., 2015; FAO, 2011).

The KAZA-TFCA is a regional and international collaborative initiative to effectively manage natural resources, such as wildlife, fisheries, and forestry, that straddle boundaries in line with the conservation guidelines of the 2001 Southern Africa Development Community (SADC) protocol (Cumming, 2008). Fish decline in this region is a serious concern among different actors along the Agro-fisheries value chain (Matthews, 2016; SADC, 2019). For more than a decade now, transboundary fisheries management efforts have attempted to scale up conservation to a larger scale (Malasha, 2005; Peace Parks, 2019; Purvis et al., 2003). However, these efforts have encountered numerous roadblocks, and fish decline and illegal fishing practices are still widely

reported (Tweddle et al., 2015; Cole et al., 2018; Irvine et al., 2019; Tweddle & Hay, 2021). As thepopulation increases and exerts pressure on the entire Kavango–Zambezi River system, the need to have a viable transboundary fisheries management regime is crucial (SADC, 2001). In 2006, several stakeholders, such as Peace Parks, the Southern Africa Development Community, and political actors, such as Nelson Mandela, initiated the idea of a transboundary natural resources management in the world's largest transfrontier conservation area, the KAZA-TFCA (Peace Parks, 2019; Linell et al., 2018). The initiative created an enabling environment in which communities of resource users, especially fisheries, could be empowered to participate in the "planning, management, and development of resources through their relevant institutions" (Linell et al., 2018; Lupiya, 2019). This was expected to foster socio-economic development and sustainable resource use (Linell et al., 2018).

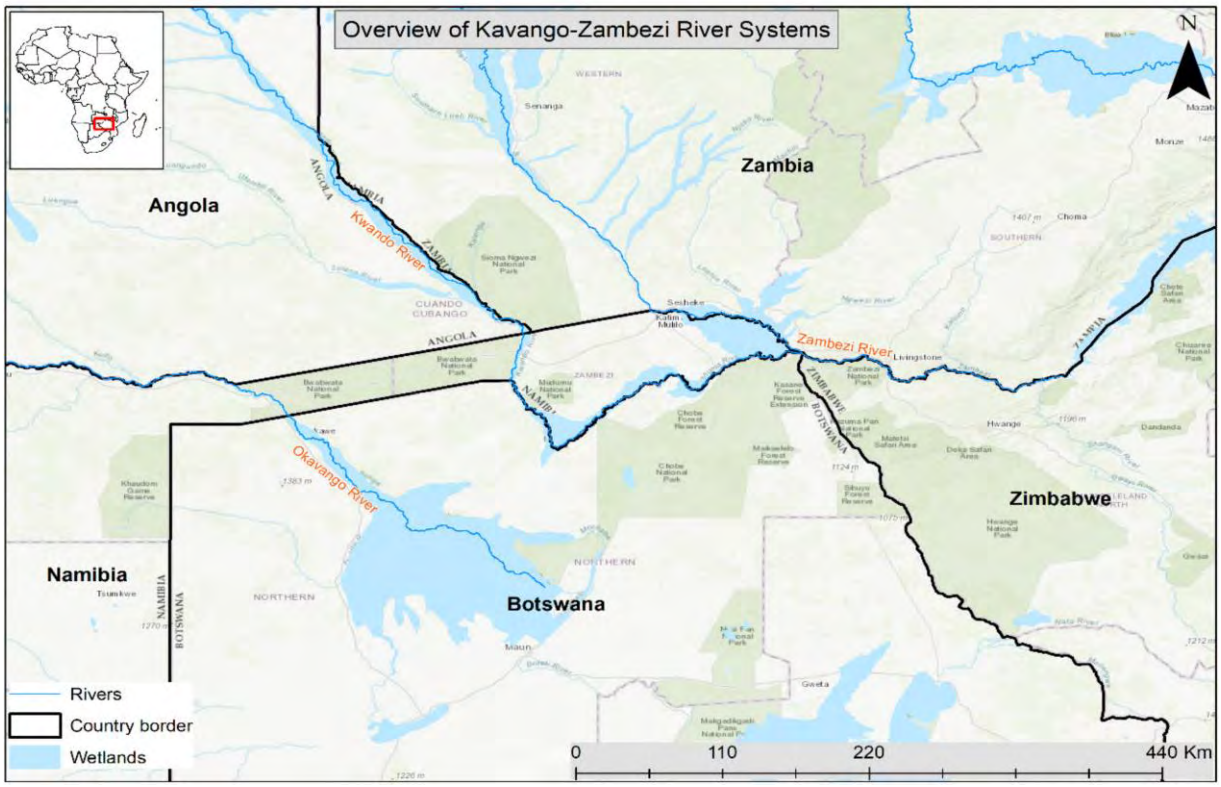

Figure 4.1 Map showing Kavango–Zambezi River system and member countries in the KAZA-TFCA

Source: adopted and modified from (Linell et al., 2018).

Although the literature cites successful cases of transboundary natural resources management through collective action responsibilities, the concept may be constrained by incompatible regulations and policies between member countries (Lupiya, 2019; Katerere et al., 2001; Njaya, 2016). This assertion calls for a standard methodological strategy in prescribing a conservation plan across the region (Coates et al., 2000).

Achieving management of this nature is no easy task in a social and ecological system characterised by diverse layers of governance (Katerere et al., 2001; Njaya, 2016; Coates et al., 2000). It is noteworthy that while management requires implementation at a local level, initiatives made at the national and regional level are critical to link both local and international requirements (Whande et al., 2006). This review is based mainly on the cited literature, through examining diverse resource management practices, and our active participation in regional fisheries' technical consultation meetings in the region. The focus is on reviewing the institutions governing the management of inland fisheries in the KAZA-TFCA and how they affect the utilisation of fisheries resources for food security and biodiversity conservation. The study will provide a window of opportunity to set out management options that can inform conservation practices and policy reforms across the African landscape. It is against this background that this paper seeks to: (i) review the institutions governing the management of inland fisheries in the KAZA-TFCA within the context of the mentioned socio-political and economic contexts; (ii) examine challenges affecting the implementation of transboundary fisheries management in the region; and (iii) outline possible interventions to optimise the utilisation of the fisheries for food security and biodiversity sustainability.

4.3 Methodology

4.3.1 Study Area

The KAZA-TFCA has one of the largest thriving transboundary fisheries in Africa and holds 85 forest reserves, 11 sanctuaries, 20 national parks, and 103 wildlife management areas (Cumming, 2008). The primary objective was to foster transboundary collaboration in implementing ecosystem and natural resource management in the region that straddles the boundaries of five countries (Cumming, 2008; Peace Parks, 2019). Fisheries in KAZA-TFCA are among the most important economic activity for the five partner countries. The starting point was an electronic search on the Food and Agriculture Organization of the United Nations (FAO) country profiles website (http:// www.fao.org/countryprofiles/en/) (accessed on 14 June 2021). Two methods of accessing data relevant to the topic of study in the KAZA region included: (i) FAO country profiles; (ii) internet searches using the country name; and (iii) specific keywords related to the management and governance of inland fisheries in the KAZA-TFCA. Each country's profile was downloaded, and the heading on fisheries' constraints and institutional frameworks was used to extract the titles of relevant information. An internet web search was used to find information that could not be accessed in the FAO country profile through the references listed within the identified literature. Titles were copied and pasted into a Google Scholar search, the outcome of which provided an array of related literature on the topic of study (Potts et al., 2019).

The study further used proceedings from the regional stakeholder workshop conducted in 2018 in Namibia to better understand fisheries' management practices at national and regional levels. Key informant interviews were held alongside the regional stakeholders' workshop. The selection of key informants followed a purposive random sampling technique which is useful for generalisations, since it was not feasible to

interview all the participants (Potts et al., 2019). A total number of 10 key informants were identified, based on the list of participants obtained from the KAZA secretariat (n = 10). Five (5) of these participants were representatives (fisheries officials) from each participating country, three (3) participants were drawn from each participating stakeholder group, namely the Namibian Nature Foundation (NNF), the World-Wide Fund (WWF), and the KAZA secretariat. Two (2) participants were members of participating fisher community conservancies from Namibia and Zambia (Situnga and Simalaha conservancies, respectively). The idea was to verify the accuracy of secondary data sources (Carter et al., 2014). The interview questions were based on success, opportunities, and challenges of transboundary fisheries management in the region. This information was used for analytical work. Finally, our experience and knowledge of the fisheries of the area as researchers, and our work experience for many years from 2000 up to the present as fisheries officers in the area was utilised. The experience helped to broaden the understanding of challenges and success stories of managing transboundary fisheries resources over time, especially on issues related to power relations. The United Nations's Food and Agriculture Organisation Code of Conduct for Responsible Fisheries was employed (FAO, CCRF) as a conceptual framework, together with related technical guidelines, such as the precautionary approach. The CCRF recommendation is based on science and experience, promoting collaboration arrangements among member countries and sharing resources that straddle boundaries. Its tenets support community participation in the management of resources; it is generally acknowledged as an ideal way of fostering effective governance (Jentoft & McCay, 1995; Griffin et al., 1999). Furthermore, the CCRF provides guidance on policy formulation, which is often a missing link in the operationalisation of fisheries activities in most of the developing countries (Jentoft & McCay, 1995).

4.3.2 The Rationale behind Transboundary Fisheries Management in the KAZA-TFCA

Transboundary fisheries management in the KAZA-TFCA was coined within the context of SADC regional integration and collaboration management of shared resources as a key to the sustainable utilisation of natural resources (SADC, 2019). The term 'transboundary' is defined in the context of international collaboration (Njaya, 2016; Griffin et al., 1999) and refers to the development of co-operation across boundaries to enhance the efficiency of achieving objectives of natural resource use and conservation (Adams & Hulme, 2003; Muchapondwa & Ngwaru, 2010). Griffin et al. (1999) defined it in a similar way, but added that transboundary management should benefit the parties involved in the initiative. Socio-ecological systems are interconnected in temporal and spatial terms, where the extent of organisation and decisions made in a particular place affects the environment and people elsewhere (Adams & Hulme, 2003). Consequently, the concept of 'bioregionalism' recognises that ecosystems do not overlap with political boundaries (Griffin et al., 1999). As well as the global recognition necessary to promote collaborative arrangements in the management of shared inland fisheries, most threatened inland fishes require distinct habitats for growth, feeding, refuge, and reproduction such as migration constitutes an inherent characteristic in their life cycle (Muchapondwa & Ngwaru, 2010; Valbo-Jørgensen et al., 2009). Therefore, political boundaries must not limit conservation at a larger scale. The idea is to sustain biological and socio-economic gains from aquatic resources that straddle several countries to reduce habitat fragmentation (SADC, 2001; Linell et al., 2018). Evidence of increased fishing pressure on inland fisheries shared by various countries has been widely reported (Ogutu-Ohwayo & Balirwa, 2004; Tweddle et al., 2015), suggesting that fisheries conservation efforts can no longer be implemented in isolation. Therefore, the transboundary management

approach to aquatic resource is necessary for responsible fisheries.

4.3.3 Conceptualizing Transboundary Fisheries Management in KAZA-TFCA

The Kavango–Zambezi River system and its network of tributaries is among Southern Africa's most important natural resources (Linell et al., 2018). Governance and management approaches for inland fisheries in the KAZA-TFCA are examined to contextualise constraints regarding the implementation of transboundary fisheries management. This information is then used to prescribe potential interventions for transboundary fisheries management in the KAZA-TFCA. According to the FAO Code of Conduct for Responsible Fisheries, the overall goal of fisheries management is based on sustainable resource utilisation (FAO, 1995) which implies: (i) maintaining the fish stock at the level required to ensure their continuous productivity; (ii) profit maximization of the resource user (fisher), and (iii) optimum employment opportunities for fisher-dependent communities (FAO, 1995). The simultaneous optimising of these objectives is rarely achieved (Kefi & Mofya-Mukuka, 2015). For instance, the maximum exploitation of fisheries for employment opportunities means intensifying fish exploitation, which may abrogate the FAO-CCRF conservation objectives (Nyikahadzoi et al., 2017). As a result, identifying a suitable management approach in a shared social and ecological system can be complex owing to diverse regulations and conflicting policies among member countries (Linell et al., 2018). These regulations are fundamental for the successful management and development of fisheries (Cole et al., 2018). While transboundary fisheries management has been widely accepted, it is moderately practised, based on a classical fisheries management approach, such as fishing ban seasons, gear and mesh size restrictions, among other tools (Haambiya et al., 2016; Pauly, 1997). Classical fisheries management in Africa is partly based on ideas drawn from Hardin's

‘Tragedy of the Commons’ model; the basic approach to natural resource management has been to privatise the common resources (Hardin, 1968). Subsequently, Pauly (1997) introduced the idea of a quota system as an option to privatisation of the commons, essentially to incorporate some form of ethics in management regimes (Pauly, 1997).

Apparently classical management approaches in tropical fisheries are subject to debate on whether anthropogenic activities (artisanal fisheries) have a huge impact on the fish productivity (Tweddle & Hay, 2021; Hardin, 1968). Several researchers (Mosepele & Kolawole, 2017; Tweddle & Hay, 2021) argue that in tropical fisheries, the correlation between human activities and the level of the future fish stock has no considerable impact; it is characterised by uncertainties, where placing a maximum level of fishing effort may not lead to a fixed state of fishing mortality (Nyikahadzoi et al., 2017). Thus, fish stock abundance and distribution are largely influenced by environmental parameters, such as river flows that are seasonally driven by the amount of precipitation received in the catchment (Nyikahadzoi et al., 2017). Several studies (Ogutu-Ohwayo & Balirwa, 2004; Tweddle & Hay, 2021; Pauly, 1997), have shown that the classical management perspective is incongruent with the nature and dynamics of inland fisheries in tropical regions, because it does not account for external factors, such as flooding nutrients (humus, cow and wildlife dung, or the build-up of organic matter, which contribute to biological productivity in tropical inland fisheries) (Jul-Larsen et al., 2003). It is further argued that the classic management approach is derived from temperate regions used in marine single-stock management; these classic approaches have based their foundation on a single-species harvest (Jul-Larsen et al., 2003). They are replete with a ‘hypothetical’ equilibrium model for the management of marine fisheries (Pauly, 1997). These models use the idea of maximum sustainable yield (MSY) as the basis of management, which assumes a standard parameter system in fisheries exploitation (Niw, 2007). Attributes of

this concept led to the introduction of mesh size and fishing effort regulations (Pauly, 1997). The classical fisheries management approach restricts the weave size of fishing nets with the goal of restricting smaller fish catches (Hackenberg et al., 2022). Over time, evidence has shown that certain fish species in flood plain environs are naturally small, even as adults, for instance, the cyprinids. Thus, excluding their catch affects the utilisation of the fishery for food security (Hackenberg et al., 2022; Mosepele & Kolawole, 2017). Although the use of classical management approaches has been questioned in tropical inland fisheries, their application in their management is so great that the tenets of the Code of Conduct for Responsible Fisheries demand that decisions can be made based on experience and existing science to support available management options (FAO, 1995).

4.4 Results

4.4.1 Governance and Management of Fisheries in Zambia

Fisheries and aquaculture development in Zambia is placed under the Department of Fisheries in the Ministry of Fisheries and Livestock. The Fisheries Act No. 22 of 2011 is a principal piece of legislation governing fisheries, together with Regulation No. 24 of 2012 (GRZ, 2011). The Act stipulates the establishment of fisheries management areas and the decentralisation of fisheries management that includes community involvement in the enforcement of fisheries regulations (GRZ, 2011). These regulations include fish gear, type, mesh size restrictions, and the issuance of fish licences to regulate fishing effort and access to the fishery areas. However, the regulations do not specify the number of fishing nets a fisher can use (Malasha, 2005; Whande et al., 2006). The fish closed season is annually imposed from 1 December to the end of February as a way of protecting the fish stock during the production phase to ensure successful recruitment (Matsuda & Abrams, 2006). This regulation has been largely criticised in tropical

fisheries owing to insufficient data in support of it (Mosepele, 2014; Abbott, 2007) which may also be relevant for inland freshwater fisheries. Several researchers (Purvis et al., 2003; Tweddle & Hay, 2021; Mosepele, 2014) have argued that floodplain fish species have different life cycles and natural fluctuations in recruitment are triggered by flood regimes (Tweddle & Hay, 2021).

At present, the fisheries sector in Zambia does not have a stand-alone policy on the management aspect of fisheries and aquaculture (Kefi & Mofya-Mukuka, 2015). The policy statement is covered by the National Agricultural Policy (NAP, 2004–2015) that governs the development of the agriculture sector in Zambia (Kefi & Mofya-Mukuka, 2015). A close analysis of interventions in the NAP shows more emphasis on crop production than on fisheries development. Furthermore, the policy focuses on maximising fish production and employment opportunities than on sustainable utilisation of the fisheries resource (Nyikahadzoi et al., 2017). This approach poses a management dilemma due to a lack of adequate fisheries data on which to base effort restriction. While fisheries co-management is enshrined in the Zambian Fisheries Act No. 22 of 2011 (Matsuda & Abrams, 2006), the Act does not explicitly exhaust matters related to transboundary fisheries management and lacks a comprehensive legal framework to support legal certainty of the fisheries development agenda (Whande et al., 2006). The lack of an adequate national fisheries policy in Zambia seems to explain why the fisheries sector has received very little attention in terms of funding (The WorldFish Center, 2007). This shortfall has, in turn, resulted in a failure to bring about the institutional reforms necessary to enhance the utilisation of the fisheries resources both at local and international levels (Mosepele & Kolawole, 2017). These claims are supported by the WorldFish Center (2007) report, which revealed a low priority of data collection accorded to the Zambia fisheries.

The system of fisheries governance on the Zambezi River in Zambia is characterised by two parallel governance structures, the central government and the traditional authorities, which are often at odds with each other (Madzudzo et al., 2013). Tension and disagreement have often arisen between the central government and the traditional authorities over leadership roles in the governance of the fishery (Cole et al., 2018). The main attributes of the local leadership in the area are: (i) fishing access restrictions; (ii) enforcement and punitive measures, and (iii) traditional fishing wardens (Cole et al., 2018). The system of governance by the traditional authorities exercises authority that allows access rights for the kingship where migrant fishers get authorisation from local headmen to settle in seasonal camps during the fish-ban period (Cole et al., 2018). According to a key informant from the Simalaha conservancy, these conditions are likely to stymie the development of a transboundary fisheries management regime because of the existing parallel and conflicting governance structures in the fishery (Cole et al., 2018). The contentious issues are on the aspect of a fish-ban season; the traditional leadership does not fully support the idea of a fish ban due to limited livelihood options and failure by the government to recognise access rights (Cole et al., 2018).

4.4.2 The Zimbabwean Context

The governance of fisheries in Zimbabwe is under the Zimbabwean Parks and Wildlife Management Authority (ZPWMA) which falls under the Ministry of Environment and Natural Resources (Mosepele & Kolawole, 2017). The Authority bears the responsibilities for wildlife (terrestrial) and fisheries management in terms of the Wildlife Act – Chapter 20:14 of 1996. The Act outlines fisheries regulations, aquaculture, and the development and control of the fishing industry. It also stipulates financial provisions, enforcement, penalties, and offences, including general provisions. Access to fishery areas in Zimbabwe is regulated through a licence system (Ndhlovu et al., 2017). The

annual system of licensing stipulates where one can fish and how many gillnets a fisher can use (Whande et al., 2006). Fish gear and mesh size restrictions are regulated to control fishing effort.

The annual licences are issued by the ZPWMA upon payment to the ZPWMA and is done in consultation with local authorities (District Councils) (Ndhlovu et al., 2017). This approach has often created user conflicts between government authorities and local resource users whose livelihoods depend primarily on access to the fishery resources (Whande et al., 2006). The resource users appear to play no significant role in the management of the fisheries resources (Mhlanga & Mhlanga, 2013), suggesting that the fisheries governance and management in Zimbabwe is a centralised 'top-down' approach. The scope of involvement by local resource users in the process of decision-making with regard to management and utilisation of the fisheries resources is very low, despite the fact that the participation of resource users in management of their resources is acknowledged as a requirement for sustainable development of the fisheries resources (Mhlanga & Mhlanga, 2013). In 1995, the FAO recommended that active engagement of resource users and stakeholders' participation in fisheries management should be among the major principles in the implementation of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). Sustainability of inland fisheries resources in Zimbabwe has received wide criticism (Nyikahadzoi et al., 2017; Mhlanga & Mhlanga, 2013) based on the argument that the top-down management approach has resulted in regulations that are inappropriate for local resource users (Mhlanga & Mhlanga, 2013). Like many other countries in Southern Africa, Zimbabwe does not have a national fisheries policy (Mosepele & Kolawole, 2017). According to Mhlanga and Mhlanga (2013), this explains why the country lacks appropriate interventions related to the role of the fishery sector in the national economy (Mosepele & Kolawole, 2017). This suggests that the lack of a

national fisheries policy in Zimbabwe has hindered institutional reforms that would have activated stakeholders' participation in decision making regarding fisheries management at a local level (Viswanath et al., 2013). Mosepele and Kolawole (2017) observed that the lack of a clear fisheries policy direction in Zimbabwe has resulted in a weak management system, which is insensitive to local conditions and less likely to meet its own objectives (that is, sustainable utilisation of the resource). The principal piece of legislation governing fisheries activities (the Parks and Wildlife Act) appears to be skewed towards management of wildlife rather than fisheries. As a result, fisheries are not accorded the necessary reforms to unleash their potential (Mosepele & Kolawole, 2017). While Zimbabwe is a signatory to regional and international protocols on responsible fisheries, the commitment to these protocols is low and the process of institutional reforms in fisheries has stagnated owing to lack of policy direction.

4.4.3 The Botswana Context

The management of fisheries resources in Botswana is under the purview of the Environment, Wildlife and Tourism Ministry (Mosepele & Kolawole, 2017). The sector is run under a division within the Wildlife sector. The Fisheries Protection Act 42 of 1975 is the principal legislation governing the fisheries activities in Botswana, together with other pieces of legislation, such as the Fisheries Protection Regulations of 2016 and the Statutory Instrument of 2015 (Mosepele & Kolawole, 2017). The latter regulates fishing effort with gear and mesh size restrictions (Mosepele & Kolawole, 2017). Permissible fishing gears in Botswana include long lines, gillnets, and hook and line. The fish-ban season is implemented for two months in January and February to protect fish breeding and recruitment during that period. However, the timing of the fish-ban season remains a challenge, as it does not coincide with the fish-ban season in Namibia and Zambia, where the ban is observed for three months from December to February (Madzudzo et al., 2013).

Botswana does not have a fisheries policy on which management interventions are based (Mosepele & Kolawole, 2017), which suggests that management measures made without a policy may not adequately address the management concerns of the fisheries sector owing to a lack of policy direction. The fisheries sector in Botswana falls under a Wildlife Management Authority whose management philosophy is focused more on conservation than sustainable exploitation of the fisheries for food security, as prescribed by FAO Code of Conduct for Responsible Fisheries (Adams & Hulme, 2003). This system of governance appears to focus on the development of wildlife to sustain the tourism sector rather than the conservation of the fisheries resources for food security (Mosepele & Kolawole, 2017). The problem is amplified by the lack of clear policy direction to bring about appropriate technologies and informed decision making. The major challenge is that investment in the research of the fisheries to generate the data required for development is not adequate (Mosepele & Kolawole, 2017), as is the lack of a stand-alone policy to provide oversight and direction on fisheries management and development. The current management approach is insensitive to the access rights of fishing communities (BIDPA, 2008; Mhlanga & Mhlanga, 2013; Viswanath et al., 2013).

4.4.4 The Namibian Context

Governance of inland fisheries in Namibia falls under the Ministry of Fisheries and Marine Resources (MFMR) (MFMR, 2017). The Inland Fisheries resources Act No. 1 of 2003 is the principal piece of legislation governing the inland fisheries in Namibia. The Act is developed in the contest of the white paper on the Responsible Management of Inland Fisheries in Namibia (GRN, 2003). Namibia is one of the few countries with a policy dedicated exclusively to inland fisheries. The underlying philosophy is that different management approaches are devised for different river systems owing to the diverse nature of some of these systems. Furthermore, the interest of the subsistence

households on the availability of fish as food security and the need to control any commercialisation of the resource are given priority. The Act provides for the conservation of aquatic ecosystems and the sustainable development of inland fisheries resources (GRN, 2003) and also recognises the transboundary management of fisheries of a shared river system (GRN, 2003). Furthermore, the management system provides for fisheries reserves, defined, regulated, and enforced by local resource users. A closed fishing season for the river systems, exclusively for the Zambezi Region is in place from the 1 December to the end of February, similar to that of Zambia. The current management approach to fisheries on the Namibian side of the Zambezi River is administered by both the traditional authority and the central government (Tweddle & Hay, 2021). The management strategies include effort restriction in the form of fishing gear restriction and type allowed, the number of gillnets allowed per fisherman, mesh size restriction, and the fishing method practised (GRN, 2003; Kavango-Zambezi Transfrontier Conservation Area 2006). Fisheries reserves are not necessarily no-take zones and may allow fishing with specific rules, according to the demands of the local communities. These rules, however, must be within the framework of the Inland Fisheries resources Act (Hackenberg & Hay, 2022). A Standing Operating Procedure (SOP) was developed, endorsed by the Ministry of Fisheries and Marine Resources, to give guidance when creating fisheries reserves (Hackenberg & Hay, 2022; NNF, 2020; NNF, 2017). Furthermore, the tackle box for community fisheries reserves highlights the step-by-step approach to establish community-based fisheries reserves (NNF, 2017). The traditional leadership plays a vital role in the management of the fisheries resources (NNF, 2022) and needs to be considered for future management approaches. Regulations place emphasis on fish gear restrictions and access rights to particular fishing grounds; they do not restrict access to any fishing area during the high-water period (MFMR, 1995; Hay,

et al., 2020; Jacobs, et al., 2022). However, permission is needed for fishing in secluded areas during periods of low-water levels (Oglethorpe et al., 2018). The Namibia Nature Foundation conducted numerous frame surveys in the Kavango, Kwando, Zambezi, and Chobe Rivers to gain insight into the value fish play in these communities, how fish are managed through local communities, and into the livelihood strategies communities pursue. Although the Namibian inland fisheries policy of 1995 has been reported to have a more influential profile due to its transparent attributes (Hackenberg et al., 2022), the system of community participation in fisheries management appears to be moderated.

4.4.5 The Angolan Context

Inland fisheries on the Kavango–Zambezi rivers system in Angola have remained underdeveloped partly due to lack of a policy to guide governance processes. The 27-year post-civil war that destroyed infrastructure had dragged institutional processes to establish policies and regulations for Government of the Republic of Angola (GRA) (GRA, 2021). The scanty information available has revealed institutional problems and processes in explaining the underdevelopment of the inland fisheries sector in Angola. Key informant interviews from both the KAZA secretariat and fisheries official from Angola revealed that the management of inland fisheries in Angola is under the jurisdiction of aquatic biological resources of 2004 (LRBA), Law-A/04 of 8 October 2004 (NNF, 2020). The law focuses on the protection and sustainable use of aquatic resources. The role riverine communities play in the protection of these aquatic resources is recognised. Recently, policies moved towards a more community-based attempt where communities have the right to manage their natural resources (GRA, 2021). Managers still lack knowledge of community-based approaches in fisheries management, and this lack of knowledge is still seen as an obstacle in establishing fishing zones that should be managed by communities for their own benefit. The Presidential Declaration 139/13 of

24 September 2013 regulates the Law on Aquatic Biological Resources with regard to inland fisheries (GRA, 2013). The purpose is to establish rules governing the conduct of inland fishing activities in the inland waters of the Republic of Angola. Some regulatory mechanisms in the law are: developing management plans for all inland fisheries, defining fishing zones and protected areas, and setting fishing effort limitations, minimum sizes of fish species, prescribed mesh sizes, and fishing methods. The law further makes provision for the consultation with fishermen associations and community organisations, and the devolution of power to the local level (GRA, 2013). Provision is also made for closed seasons, although no current closed fishing season is in place. Recent training of staff on sampling and survey protocols was done between Namibia and Angola with the aim of establishing a shared database for management purposes in the future. Similar activities were performed in the establishment of fisheries reserves with the aim of having these reserves across borders, managed by communities on both sides of the river (MFMR, 1995). Most investment in subsistence fishery is in the coastal fisheries with very little channelled into inland fisheries. While Angola appears to have sustainable fisheries strategies and plans, these have not been implemented owing to lack of a policy framework to stimulate policy debate on inland fisheries and guide governance processes (FAR, 2022).

4.5 Discussion

Classical management approaches are widely used to manage fisheries in the region, which, as shown in this paper, can be problematic in various aspects. It is argued that countries in the KAZA-TFCA have different management approaches and regulations characterised by inadequate policy (BIDPA, 2008), and that assessing several regulations, policies, and local institutions in the region is cardinal before scaling up conservation measures (FAR, 2022). This paper further argues that the implementation of a

transboundary fisheries management regime throughout the KAZA-TFCA has largely failed. We hold the idea that transboundary fisheries management has shown positive results as a management concept in diverse sectors of natural resources governance, including fisheries (Njaya, 2016; Jentoft & McCay, 1995) and theoretically, it shares a number of advantages of bottom-up management (Katerere et al., 2001). The fundamental difference in the regulatory frameworks, management approaches, and inadequate policies governing the fisheries resources in the region has created a stalemate for the successful management of aquatic resources. This has serious policy implications for transboundary fisheries management in the region and elsewhere in the world (Aswani et al., 2017). Implementation of transboundary management as a blueprint without harmonising the fisheries regulations, policies, and management approaches is a constraint on conservation and a sustainable livelihood for local residents. This may further limit conservation at a larger scale because of incompatible fisheries regulations that may result into wide-spread free-riding activities (Hardin, 1968; BIDPA 2008).

4.5.1 The Dilemma of Transboundary Fisheries Management in the KAZA-TFCA

The fisheries regulations that exist across the countries in the KAZA-TFCA make the actualisation of transboundary initiatives difficult. For instance, within the KAZA-TFCA, recreational fisheries in Botswana, Namibia, and Zimbabwe are allowed throughout the year, even during fish-ban season, while in Zambia, recreational fishing is prohibited during the fish-ban period. This conflicting regulation over the utilisation and accessibility of the fishery resources during the fish ban has affected co-operation of shared management responsibilities among member countries, especially at local level (Aswani et al., 2013). Similarly, the implementation of a fish-ban season of three months observed in Zambia and Namibia from December to February the following year, essentially to cover for the fish breeding season for most fish species in the Zambezi River

system (Purvis et al., 2003), is in conflict with the two-month ban enforced in Botswana between January and February, while Zimbabwe does not observe this ban at all (Mosepele & Kolawole, 2017). The situation creates considerable challenges for transboundary fisheries management on the Kavango–Zambezi River system owing to free-riding activities by fishers in countries that do not implement a fish ban (Carter et al., 2014). Furthermore, the efficiency of the fish-ban season to allow fish breeding and recruitment is questionable because the timing does not coincide with the breeding period of most of the targeted fish species, such as the Tilapine fish species. Most of these fish species breed around October–December. This situation is perceived to cause resentment among various stakeholders and to reduce the overall effectiveness of transboundary fisheries management at the local level (Purvis et al., 2003).

The Zambian fisheries policy emphasises the maximum fisheries production to meet the food requirements of the growing population and to secure employment opportunities for rural communities (Nyikahadzoi et al., 2017). As a consequence, many small-scale fishers who can afford entry into the fishery are allowed unfettered access, without gillnet limitations (Nyikahadzoi et al., 2017). This approach may lead to over-exploitation, the tragedy of the commons, and compromises the sustainable utilisation of the fisheries resources as prescribed by the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). This further conflicts with the fishing regulations of neighbouring countries, such as Zimbabwe, Namibia, and Botswana, where fishing effort is regulated by limiting the number and size of nets a fisher is allowed to use. Conversely, the Zimbabwean fisheries regulations appear to restrict and regulate the number of gillnets a fisher may use and to stipulate where one can fish (Nyikahadzoi et al., 2017; Mhlanga & Mhlanga, 2013). Artisanal fishers are restricted entry to certain fishing grounds (Nyikahadzoi et al., 2017). This kind of management approach appears to focus more

attention on recreational fisheries and wildlife activities to support eco-tourism than on utilisation of the fishery for food security, despite the fact that tourism conservation is not likely to create better opportunities and equal access to resources for rural riverine communities whose livelihoods depend on fishing (Whande, et al., 2006).

The differences in management approaches have generally made it difficult to actualise transboundary initiatives, as different countries within the region appear to pursue diverse social economic models of development. These differences affect coordination and collaboration among participating countries at a local level (Aswani et al., 2013). For instance, the five countries in the KAZA-TFCA have pronounced policy statements in favour of transboundary fisheries management, but the existing divergent economic policies among member countries hinder meaningful implementation of equitable shared responsibilities (Whande et al., 2006; Nyikahadzoi et al., 2017). Key informant interviews from both Zambia and Zimbabwean officials revealed that there are differences with regard to mesh size prescribed by Zambian fishing regulations and those of Zimbabwe. These findings are further highlighted in the 2011 Zambia/Zimbabwe Fisheries Frame Survey report, which showed that gillnets of mesh sizes below 63 mm (2.5 inch) were also reported to be used in Zambia. The nets increased from 51 in the 2006 Survey to 189 in the 2011 Frame Survey (Nyikahadzoi et al., 2017). The use of these nets (below 63 mm) is prohibited in Zimbabwe. These differences in the regulations of inland fisheries complicate transboundary fisheries management at the local level and create a social dilemma for a person's rational behaviour, in which the absence of limits to maximise short-term personal gain may result in environmental degradation (Young, 2006). It is difficult to realise the fisher's incentive to cooperate over resource conservation as opposed to harvesting as much as possible since fish, by nature, are fugitive (Haambiya et al., 2016). The fish you do not harvest today are most likely to be

harvested by someone else tomorrow (Young, 2006; Ostrom, 1990) leading to the tragedy of the commons.

Given the above scenario, it is apparent that a lack of compatibility in fisheries regulations between nations in the KAZA-TFCA is a huge challenge for the successful implementation of a transboundary management regime. The problem is exacerbated by inadequacies in and the lack of national fisheries policies among the member countries (Mosepele & Kolawole, 2017; Weyl et al., 2007). This is particularly evident in the failure to optimise usage of the many dams in Zimbabwe and south-eastern Botswana for fisheries production (Mosepele & Kolawole, 2017). It is acknowledged that the overriding objective of fisheries management is the biological sustenance and utilisation of fisheries resources to support the economic and social wellbeing of fishers (Jacobs et al., 2022). Consequently, the development of transboundary fisheries management must be guided by a policy framework to guide the governance and utilisation of the resource for food security at both national and international levels (Oglethorpe et al., 2018).

Apparently, the management of fisheries in Botswana and Zimbabwe is run under a division within the Wildlife Management Authority. The challenge with this institutional arrangement is that both wildlife terrestrial and fisheries resources are managed for conservation to sustain tourism, since recreational fisheries integrate so well with tourism (Mosepele & Kolawole, 2017). This management approach denies resource users real opportunities to utilise the fisheries for food security, as prescribed by the FAO Code of Conduct for Responsible Fisheries (Mosepele & Kolawole; FAO, 1995).

The placement of the fisheries division under the wildlife sector has a negative bearing on the performance of the fisheries sector because of the frequent and unpredictable institutional changes in the wildlife sector, which is often influenced at the global level (Mosepele & Kolawole, 2017). The conditions whereby fisheries

management is a responsibility of the Parks and Wildlife Authorities is a compromise as these sectors are not 'development' orientated (Mosepele & Kolawole, 2017; Oglethorpe et al., 2018). In other Southern African countries where fisheries have a relatively established institutional profile (such as Malawi and Mozambique), transboundary fisheries management has been relatively successful (Njaya, 2016), for instance, the establishment of a vibrant transboundary fisheries management scheme on Lake Chiuta, shared between Malawi and Mozambique. The achievement of the recently coordinated regulations in that fishery was a prerequisite to a successful implementation of a transboundary fisheries management in the lake (Njaya, 2016). While the idea of transboundary fisheries management has been widely recognised since the 1980s, it has recently grown in prominence through institutional reforms and collaborative initiatives (Rivera-Torres & Gerlak, 2021). For instance, a more creative partnership between the United States of America and Mexico illustrates the creation of joint solutions to environmental challenges of a shared Colorado River basin (Rivera-Torres & Gerlak, 2021). In the Laurentian Lakes, where the United States of America and Canada have set up management structures to address policy and environmental issues, a harmonisation of policies played a key role in establishing management structures (UNU-INWEH, 2011). In the African Great Lakes region, a collaboration initiative is newer. Diverse governance systems among the riparian states sharing Lake Victoria, for example, have been among the major hindrances to the effective management of the lake ecosystems (UNU-INWEH, 2011). The fundamental variations in the utilisation of fisheries resources in the KAZA-TFCA show dissimilar behaviour in resource exploitation and conservation, thereby making conservation prescription very difficult (Carter et al., 2014; Oglethorpe et al., 2018).

Overall, these accounts suggest how coordination and harmonisation of

regulations between partner states could be an essential aspect in making transboundary fisheries management sustainable on a long-term basis. According to Ostrom (1990), the governance of social and ecological systems will have a positive outcome only if sufficient conditions are incorporated in the management aspects. As such, Ostrom identifies eight interrelated design principles for the effective management of resources held in common. Principle design numbers 6, 7, and 8 are based on the existence of a mechanism of conflict resolution, the recognition of rights to self-organise, and a framework for co-ordination among relevant stakeholders, respectively (Young, 2006; Ostrom, 1990). Application of these principles have the scope to achieve collective responsibility for transboundary fisheries management in the KAZA-TFCA and elsewhere (Valbo-Jørgensen et al., 2009; Wilson et al., 2012). The absence of the aforementioned principles may lead to user conflicts, non-compliance with rules governing the resources, and free-riding activities. The interactive effects of abrogating these principles in the management of transboundary fisheries contradicts the sustainable utilisation of fisheries resources as prescribed by FAO Code of Conduct for responsible fisheries and may weaken the initiatives of transboundary fisheries management both at local and international levels (Whande et al., 2006; Coll et al., 2013).

4.5.2 Prospects for Transboundary Fisheries Management in KAZA-TFCA

Several studies, so far, show that fisheries in the KAZA-TFCA have the potential to contribute to the food security and nutritional status of over one million people who regularly eat fish in the region (SADC, 2019; Purvis et al., 2003; BIDPA 2008). A standard approach to support transboundary fisheries management is necessary to guarantee future prospects. (FAO, 2022; SADC, 2022), It is generally acknowledged that transboundary initiatives can enhance security, peace, and the long-term stability of people and

resources. These goals can be actualised by recognising regional and international protocols to which all member countries discussed here are signatories. Management of transboundary inland fisheries in Southern Africa, to a large extent, stems from the SADC protocol of 2001, whose principles were founded on the United Nations Convention on the Law of the Sea 1982 (UNCLOS) and the principles of the FAO Code of Conduct for Responsible Fisheries (CCRF) (FAO, 1995; FAO, 2021; SADC, 2022). In light of these findings, we propose using the FAO Code of Conduct for Responsible Fisheries of 1995 as a conceptual framework to secure and analyse the sustainable utilisation of fisheries resources in the KAZA-TFCA as a first step. The CCRF draws from experience and science-based evidence in designing international instruments, policies, and plans to support responsible fisheries management. It further declares that "States should co-operate at global, regional and sub-regional level to promote management and conservation to ensure responsible fishing" (FAO, 1995; Hackenberg and Hay, 2022). The CCRF provides important guidelines for developing good management practices and policies for sustainable fisheries and aquaculture development (FAO, 2021).

Furthermore, the CCRF provides for community participation in the governance and management of natural resources, an aspect that offers a window of opportunity to incorporate indigenous knowledge in resource management (Berkes et al., 2001). Indigenous knowledge is context specific, and local resource users often desire to use concrete knowledge in time and space (FAO, 1995; Oglethorpe et al., 2018; MEA, 2005). Although the CCRF is a voluntary code, its guiding principles are internationally acknowledged in the management of fisheries (Government of the Republic of Angola, 2013). The CCRF is complemented by several other technical guidelines on how to implement specific provisions, for example, the precautionary approach to capture fisheries (FAO, 2015). Nevertheless, designing regional and international agreements

into practical strategies will, in many cases, require commitment and backing from interested parties, in this case, member states within the KAZA-TFCA who have already signed a memorandum of understanding for regional collaboration in the management of transboundary natural resources (Peace Parks, 2019). Regional institutions, such as SADC, are critical vehicles to influence regional stakeholders.

The SADC Protocol on Shared Water Bodies and the SADC Treaty on Management of Watercourse Systems provide an opportunity for such stakeholder coordination consistent with the mission statement of the KAZA-TFCA (KAZA, 2006). The transboundary fisheries management challenges reviewed in this paper would be addressed by fulfilling certain key attributes, highlighted in Table 4.1. For instance (i) a lack of cooperation among member countries and stakeholders in KAZA-TFCA would be addressed by coordination and collaboration amongst the countries sharing the fisheries resources (Chama & Mwitwa, 2020; Muringai, et al., 2020). Collaboration among member countries will create a platform for sharing knowledge, technology, expertise, and financial resources towards meeting the regional development agenda (Chama & Mwitwa, 2020; Kapembwa et al., 2021); (ii) the inadequate institutions and inconsistencies in management approaches would be addressed by fulfilling the attribute of having strong institutional frameworks. The FAO, CCRF provide technical guidelines on policy development and essential institutions for fisheries management. Policies are intended to guide governance processes and highlight the role and responsibilities of all stakeholders who may be key to strong transboundary collaboration (Kapembwa et al., 2021).

Table 4.1 The key attributes essential for successful implementation of Transboundary Fisheries Management

No.	CCRF Attributes	Rationale
i	Co-ordination and collaboration	CCRF provides policy harmonisation and the integration of management approaches. In this case, countries in the KAZA-TFCA can adapt to facilitate informal mechanisms for collaboration and conflict resolution in response to the objectives of transboundary cooperation.
ii	Strong institutional framework	CCRF stresses the need to develop institutional frameworks and policies which provide guidelines on the utilisation of the fisheries resources for food security, while taking into account compatible measures within and beyond the national jurisdiction to ensure responsible fisheries.
iii	Social-ecological approach	CCRF promotes biodiversity conservation and availability of fisheries resources in sufficient quantities for present and future generations in the context of food security and poverty alleviation.
iv	Stakeholders' participation	CCRF emphasises the need for community participation in the governance of fisheries resources. The assumption is that if communities are involved in conservation, the benefits they receive will create incentives for them to become good stewards.
v	Precautionary approach	CCRF provides guidelines to prevent and mitigate potential threats to marine and inland fisheries.

Adopted and modified from FAO, 1995; FAO, 2021.

To avoid conflicts among the stakeholders, attention has to be premised on the fact that the decision-making process incorporates all the stakeholders involved and that the strategy is multidisciplinary, that is, it involves fish traders, fishers, officers, value-chain actors, and several other resource users to sufficiently integrate indigenous knowledge and create a sense of ownership and adherence (Haambiya et al., 2016). Furthermore, Campbell and Olson (1991; Welcomme, 2007; Béné et al., 2009; Tweddle et al., 2011) argue that major decisions and priorities regarding which resources to enhance for which institutions are not arbitrary, rather they mirror the interest of the most powerful groups whose power is interceded through political, economic, and social institutions. In light of this, political influence will be essential in facilitating an enabling environment for policy reforms in transitioning to FAO, CCRF (Nyikahadzoi et al., 2017).

Other challenges discussed in this paper would be addressed by the attributes highlighted in (Table 1). Furthermore, CCRF provides for a precautionary approach towards the management of fisheries resources, which is particularly important for the KAZA-TFCA where data on which to extrapolate decisions are inadequate. A precautionary approach is widely considered as a guiding tool for policy and management decisions in times of uncertainty, as it shifts the decision-making process to anticipate, prevent, and mitigate threats (Adams & Hulme, 2003; United Nations University–Institute for Water, Environment and Health, 2011).

Several studies, for example, Coll et al. (2013; FAO, 2022; SADC, 2022), have exalted the efficiency of the FAO CCRF in fisheries' resource management, by comparing compliance with the FAO CCRF to changes in five ecological indicators, which quantifies the ecosystem effects of fishing. The loss in production index and the related probability of sustainable fishing index were tested in different regions. The results indicated that countries with higher levels of compliance with the CCRF

experienced a decrease in production index loss, and an upsurge in fisheries sustainability from the 1990s to 2000s. The study concluded that the implementation of the FAO CCRF resulted in positive ecological outcomes. However, FAO CCRF must not be seen as a universal panacea to deal with all the problems related to transboundary fisheries management; more studies and research are still needed to learn about better conditions leading to the implementation of successful transboundary fisheries management.

4.6 Conclusion

This chapter has presented a review of the fundamental differences with regard to a governance and management perspective of transboundary fisheries in the KAZA-TFCA. The study has illustrated why uniform conservation prescription matters in resource conservation. The focus of the study has been to argue that member states in the KAZA-TFCA have substantially different management approaches, except for Namibia, none of the KAZA participating countries has a fully developed fisheries sector policy to guide governance roles and processes. Regulatory frameworks are constrained by inadequate institutions, which require capacity building to strengthen coordination. This gap appears to undermine the sustainable utilisation of the fisheries resources in the region for food security, and subsequently, a transboundary management regime. The frameworks create further differences in the way the fisheries resources are accessed, managed, and utilised. The debates about fisheries governance and management are essentially to enhance livelihood opportunities for riparian communities.

The study provides useful insights into the factors constraining transboundary fisheries resources to transform the future. The findings have policy implications for transitioning a fisheries policy towards sustainable fisheries management and enhancing food security and environmental sustainability. The immediate target should aim at

stabilising the fishery by having a coordinated response involving all the partner countries and harmonising fisheries regulations and management approaches.

If these fisheries resources are managed sustainably, inland fisheries can contribute towards attaining the United Nations' Sustainable Development Goals (SDGs) of biodiversity conservation and poverty alleviation by 2030. Based on FAO reports, SDGs can be realised through poverty eradication by 2030. The first and second SDGs emphasise the need to "eradicate poverty" and "hunger" (Food and Agriculture Organisation 2022), which can be accomplished through improved rural development initiatives in fisheries and fish farming development. This is crucial and very urgent in southern Africa, where a United Nations (2016) report indicated that poverty is widespread, with about 40% of the population surviving on less than USD 1.95 per day in 2012.

4.7 Chapter summary

This Chapter has demonstrated the role of institutions in management of fisheries resources and how these institutions affect the utilisation of the resources for food and nutritional security in the region. Analysis of this study has shown inland small-scale fishing in the entire KAZA region is short-changed by inadequate institutions, because they are a determinant factor in resource accessibility, entitlement, and resource exclusion.

4.8 References

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Chapter 5

Result/ Article II: Socio-Economic and Environmental Challenges of Small-Scale Fisheries: Prognosis for Sustainable Fisheries Management in Lake Kariba, Zambia Sustainability 2023, 15, 3179. https://doi.org/ 10.3390/su15043179

5.1 Abstract

The Lake Kariba fishery is of regional importance; it accounts for 35% of the total Zambian fish production. However, emerging evidence in recent decades suggests that the fishery faces socio-economic and environmental challenges. Using Ostrom's framework for analysing socio-ecological systems, we examined the social, economic, and environmental problems faced by the fishing communities in Lake Kariba. The framework links various social, economic, and ecological factors to devise a sustainable fisheries management plan. A combination of survey questionnaires, focus group discussions, observations, and key informant interviews were used to assess this sustainability challenge. The data collected were subjected to bivariate and descriptive analysis. The results obtained did not show a significant decline in fish production over the past 13 years (R^2 Linear = 0.119, p = 0.248). However, the experts and the fishers have reported declining trends in valuable fish species such as *Oreochromis mortimeri*, compounded by the increased fishing efforts (X^2 = 180.14, p value = < 0.00001). The key threats identified include overfishing, weak institutions, and the introduction of invasive fish species such as *Oreochromis niloticus.* This situation has raised fears of fish depletion among the stakeholders. Based on these results, we recommend stronger institutional collaboration among the stakeholders in the riparian states and education that illustrates the global value of fisheries for food security and biodiversity conservation in pursuing the United Nations Sustainable Development Goals.

Keywords: Biodiversity; overfishing; environmental; socio-economic; sustainability

[2]

5.2 Introduction

Lake Kariba is a man-made lake composed of two distinct fisheries, namely the small-scale, multi-species inshore fishery, and the small pelagic semi-commercial, single-species offshore fishery for the introduced *Limnothrissa miodon* (Kolding et al., 2003). Lake Kariba accounts for 35% of the total Zambian fish production and 90% of Zimbabwean fish production (Kaminskia et al., 2018; FAO, 2020). The contribution of the Lake Kariba fishery to food security has been acknowledged in recent decades, but its role as a source of employment and income generation to many actors in the country has been grossly underestimated (Chan et al., 2021). The contribution of the fishery to food security is of great importance to the national and regional economy. This narrative makes the fishery a classic 'hot-spot' for fisheries biodiversity and a reliable source of livelihoods for the millions of people subject to the wider anthropogenic threat and conservation priority (Kolding et al., 2003). The fishery is increasingly under pressure from multiple uses, such as tourism development, recreational fisheries, semi-industrial fishing of the introduced *Limnothrissa miodon*, locally known as Kapenta, and, more recently, inland aquaculture through cage fish farming. This multiple-use competition has often disadvantaged small-scale fishers by outcompeting them for fishing space (Ndhlovu et al., 2017). The interactive effect of these human activities can negatively affect the aquatic environment in ways that lead to low fish productivity, such as by increased sediment loading and increased user conflicts (Tumbare, 2008; Ndhlovu et al., 2017; Velde et al., 2022). Over the past two decades, there have been wide reports of a declining trend in fish

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yield and shifts in the fish species composition in Lake Kariba, especially of the more valuable *Oreochromis* species (Maulu & Musuka, 2018; Musando, 1996). This trend has raised concerns about fish depletion among the local and regional communities (Chifamba & Mauru, 2017: ADB, 2021; FAO, 2021). However, it is not clear whether this situation has deteriorated or not, or how the fisherfolk have adapted to the socio-economic and ecological changes over time (Marshall, 2021). It is assumed that fisheries that are poorly managed will experience a decline in diversity (Weyl et al., 2005). The management of inland fisheries has not been adequately debated in recent policy deliberations, at either the local or the international levels, which is partly due to the inadequate data to support their value for food and nutritional security (Holling, 2001; Musumali et al., 2020). In the last 15 years, the Food and Agriculture Organisation (FAO) of the United Nations has facilitated joint international fisheries management meetings among the riparian countries sharing Lake Kariba, meetings which have continued every two years to date (FAO, 2021).

However, the success of these international engagements appears not to have been effective in addressing the conservation aspirations of the local resource users (Nyikahadzoi et al., 2017; Mhlanga & Mhlanga 2013), which is partly due to weak institutional capacity and management approaches that focus too much attention on fish stock assessment (Nyikahadzoi et al., 2017). The lake's socio-economic and environmental data have often remained relatively obscure (Nyikahadzoi et al., 2017). This oversight in the acquisition of socio-economic data has resulted in knowledge gaps essential to address food security and poverty among small-scale fishers (Kittinger, 2013). Amidst these challenges, climate change appears to exert more pressure by altering the fish habitats and the distribution patterns of these aquatic resources (Muringai et al., 2020; Magadza, 2011). The climatic trends around Lake Kariba show that the temperature will rise in the range of 1–3 °C by 2080, while mean rainfall rates are expected to decline (Ndebele-Murisa et al., 2011). The unprecedented changes brought about by the

COVID-19 pandemic are another stressor constraining conservation efforts (Hackenberg et al., 2022). The existing management approaches are under increasing pressure and are unable to cope with and mitigate the rapidly developing pressures, such as the environmental impact, overfishing, the user conflicts, and the invasion of plant and animal fish species (Mhlanga, 2009). This study, using the Lake Kariba fishery as a case study, contributes to the various studies which emphasise the need to integrate socio-economic data in fisheries management to enhance the sustainability of the inland fisheries (Magadza, 2010).

The overall objective of this study was to evaluate the nature of the small-scale fishing practices on Lake Kariba, to examine their socio-economic conditions, and to identify the environmental threats that may have negative effects on the biodiversity of the fisheries and the livelihoods of the fishers. The study also assesses how small-scale fishers have adapted to the socio-economic and environmental changes over time and suggests possible interventions to protect the fishery from further deterioration. The following research questions are addressed:

1. What are the perceived key threats to fisheries productivity in Lake Kariba?
2. How are the socio-economic and environmental conditions in the Lake Kariba fishery affecting small-scale fishers?
3. How have small-scale fishers adapted to the socio-economic and environmental changes in Lake Kariba?
4. How will the management of the Lake Kariba fishery have to change in response to the socio-economic and environmental changes?

5.3 Materials and Methods

5.3.1 Study Site

The study was undertaken in the Zambian section of the Lake Kariba fishery, a social-ecological system that emerged following the construction of a dam wall along the middle of the Zambezi River (Mhlanga et al., 2009). The dam was constructed between 1958 and 1961 to generate hydroelectric power (HEP) (Mhlanga et al., 2009). The fishery is located along the border between Zimbabwe in the south and Zambia in the north and lies between latitudes 16°28' and 18°06' south, and longitudes 26°40' and 29°03' east (Figure 5.1). By volume, Lake Kariba is the second largest artificial lake in the world, with an estimated total surface area of 5580 km^2, a length of approximately 280 km, and an altitude of 665 m at the average high-water level (Magadza, 2010). Lake Kariba was made for a single purpose, that is, hydroelectric power generation for both Zambia and Zimbabwe, but as it turned out, the lake supports a thriving small-scale fishery, hydropower generation, sport fishing, tourism, crocodile farming, and a semi-commercial fishery that contributes significantly to the economies of both Zambia and Zimbabwe, and the region at large (Ndhlovu et al., 2017). The average temperature around Lake Kariba is 28.7 °C. The fishery has vast conducive fishing zones (Ndhlovu et al., 2017; Nyikahadzoi et al., 2017), favourable for capture fisheries activities. Inland aquaculture production has grown considerably in the recent past, making Zambia the sixth largest producer of farmed fish in Africa (Tran et al., 2019). Lake Kariba now houses some of the largest cage fish farms on the African continent, with an estimated production of 17,000 tonnes per year (ADB, 2021). The two riparian countries, Zambia and Zimbabwe, share the lake at a ratio of 45% to 55%, respectively (LKFRI, 2011). The Zambian section of Lake Kariba was chosen as a study area because it represents the best-fit example of a fishery that has undergone wide socio-economic and environmental changes over the past five decades with little or no documented records on the topic of study (Magadza, 2010). A study of this nature will provide

the necessary information for improved management and policy direction in the development of inland fisheries in Zambia and the region at large (Marshall, 2021).

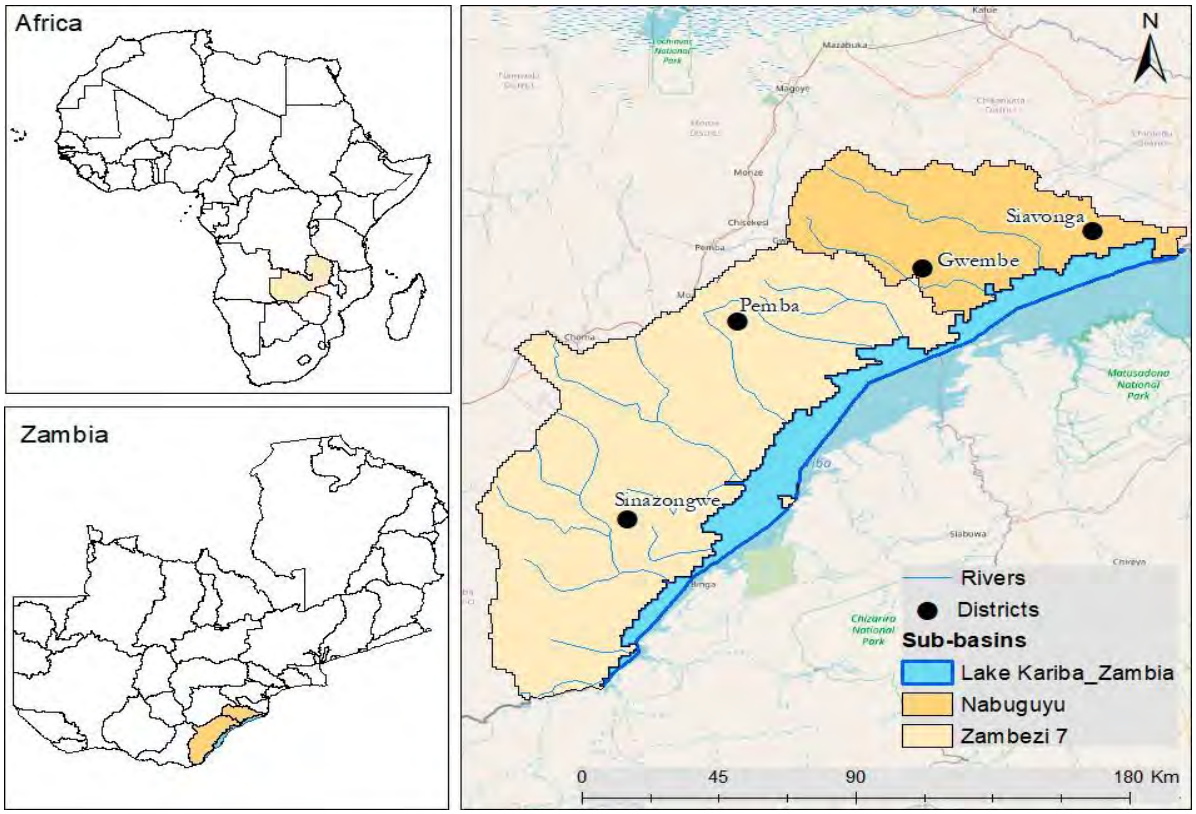

Figure 5.1 Map showing Lake Kariba, Africa and Zambia (Source: own illustration).

In accordance with the principles of Bazigos (1974), the lake on the Zambian side is divided into four different strata, based on the geographic and ecological features of the lake (Nyikahadzoi et al., 2017). These strata fall into three political districts: Sinazongwe, Gweembe, and Siavonga. Each of these districts has a collection of fishing villages ruled by a traditional chief. Ethical clearance to conduct the study was reviewed (2020-1571-4696) and granted by Rhodes University prior to the commencement of the survey. The Zambian section of Lake Kariba has 65 fishing villages and camps scattered across the shoreline (LKFRI, 2011) and the Department of Fisheries, as gatekeepers, gave us the authority to collect data from their established institutions located in the study area.

5.3.2 Sampling Design

Data collection for this study area (Figure 5.1) was undertaken from September 2020 to March 2021, using a mixed methods approach to obtain both qualitative and quantitative data (Schram, 2014). The secondary data (grey literature), such as those from frame survey reports and catch assessment surveys (CAS), were obtained from the Department of Fisheries. This information was vital for the sampling design and for a better understanding of the ecological aspects of the fishery with regard to the changes in the fish composition, the fish production trends, and the demographic characteristics of the fishery over time (Schram, 2014).

A reconnaissance survey was conducted prior to the actual data collection to comprehend the status of the fishery and to devise appropriate sampling procedures. This was necessary because the fishing communities are heterogenous, and certain elements of the population sample may not match all the particulars of the previously defined sampling procedures (Carter et al., 2014). Thus, to select the sample size in each stratum, a proportional quota sampling technique was used during the study with the help of the secretariat of the fishing village management committee (Alvi, 2020). This technique enables the researcher to obtain sample sizes in each stratum which are directly proportional to the number of participants in a targeted population (Table 5.1). In order to generalise the results of the study with a minimum level of errors, the study assumed 30% of the total of 65 fishing villages along the entire shoreline (Burgess, 1982; LKFRI, 2011), resulting in a total of 20 fishing villages where the interviews and focus group discussions were carried out (Table 5.1).

Table 5.1 Sample size population per stratum and district.

District	Stratum	No. of Fishers Sampled per Stratum	No. of Fishing Villages Sampled	No. of Focus Group Discussions per Stratum
Sinazongwe	I	125	6	**5**
	II	52	4	**3**
Gwembe	III	63	5	**4**
Siavonga	IV	60	5	**4**
Total		300	20	**16**

To validate the accuracy of the data collecting tools, 30 questionnaires were initially administered to the local participants in the study area (Sharma, 2017; Ghosh, 2020). The survey questionnaire focused on fishing practices, environmental and socio-economic conditions, such as access to social amenities, livelihood strategies, ecological aspects, and fish-marketing strategies. A total of 300 mixed survey questionnaires comprising both open- and closed-ended questions (Sharma, 2017), were administered to fishers of 20 years and older. The selection criteria of the participants (fishers) were put at a 95% confidence level from an estimated total of 2240 fishers across the four strata (Bless et al., 2013). When selecting individual participants for the survey questionnaires, a snowball sampling technique was used to identify active fishers in every targeted fishing village (Bless et al., 2013). This technique was appropriate for identifying active fishers at the village level since some of the fishers were not available on site during the survey, thus preventing access to a random sample (Sharma, 2017).

The focus group discussions (FGDs) targeted both fishers and local community members, such as fish processors, members of the public, and fish traders. Each discussion group comprised 9–14 people, thereby covering 162 participants of all genders. Each FGD

lasted about three hours and was conducted along the shoreline and in places where the participants could sit properly and be easily observed. The discussions focused on fishing practices, livelihood strategies, general constraints, and the environmental issues affecting the fishery. Focus group discussions are useful for the validation of data and an in-depth understanding of the topic of study (Carter et al., 2014). The field observations covered the surrounding environment, and fishing activities across the fisheries value chain, including fishing techniques, waste management forms, and the sewage system. Observations are an effective way of obtaining data regarding the surrounding of the study area (Creswell, 2014).

Semi-structured interviews with 18 key informants involving 11 different stakeholders in the fishery were conducted to solicit additional information on the topic of the study. The target group comprised local leaders, experienced fishers, senior government officials, and traditional leaders, such as village heads. The key informants helped to confirm and explain the earlier ideas collected from the fishers using questionnaire surveys and FGDs (Ghosh, 2020). A rapid appraisal of fisheries management systems (RAFMS) was used to identify the possible interventions for sustainable fisheries management (Alvi, 2020; Burgess, 1982). For the RAFMS, 26 well-informed community members as key informants were identified to help provide information based on their past experience, skills, and knowledge about the fishery (Kohn, 1997; Koshy, 2005; DOF, 2020). The purpose was to capture views from a broader perspective to consolidate and validate other sources of information (Koshy, 2005; Creswell, 2014).

5.3.3 Data Analysis

Before analysis, the data obtained from the survey questionnaires were coded and entered into an Excel spreadsheet for quality control (Alvi, 2020). Descriptive statistics were generated using R Version 3,9.1, 2020. The qualitative data obtained from the interviews and FGDs were analysed using a theme-based content analysis technique, which involved a process of going

through all the interviews to categorise themes with similarities (Bless et al., 2013). The quantitative data obtained during the survey were analysed using bivariate statistics (Burgess, 1982). As such, the chi-square (Pearson's $\chi 2$) test was applied to determine the increase in the fishing effort, using indicators such as the increase in the number of fishers, fishing boats, and nets between 2006 and 2011. This information was the best available information and was vital in analysing the dynamics of the demographic changes in the fishery over time. The fish production trends over the past 13 years were analysed using a curve fitting estimation regression test. This test provides the best fit for specific curves in the dataset for trend analysis over time (Burgess, 1982). All the statistical analyses were performed using the software package R Version 3,9.1 (R Core Team, 2020) to facilitate the interpretation and analysis of the data. The results obtained, together with qualitative data from secondary data sources, were used to describe the socio-economic and environmental condition of the fishery (Kohn, 1997; Carter et al., 2014).

5.4 Results

5.4.1 Fishing Practices

Lake Kariba is a diverse artificial fishery characterised by multiple user groups using a multi-method and multi-species approach to the fishery. According to the study, about 77% of the fishers in Lake Kariba appear to be 'fishing-dependent' (Table 5.2). However, the degree of dependence varies with respect to the type of fisher. The study identified three (3) categories of fishers: full-time, part-time, and seasonal fishers. However, a substantial overlap exists between these fishers. The findings of the study showed that more than half of the fishers (74%) were full-time, 12% were part-time, and 14% were seasonal (Table 5.2).

Table 5.2 Fisher information based on the 300 survey questionnaires

Fishing Information	Part-Time (*n* = 36)	Seasonal (*n* = 40)	Full-Time (*n* = 224)
No. of fishers (% total)	12%	14%	74%
Education (% literate)	22%	20%	28%
Age (years)	40 ± 7.49	24 ± 6.22	56 ± 7.8
Fishing period	13 ± 3.9	15 ± 3.7	27 ± 4.9
Gender	-	-	-
Male	24	35	230
Female	6	5	-

The focus group discussion revealed that the average fish catches per unit effort (CPUE) were between 1.5 kg and 2.5 kg for the full-time fishers and 1.5 kg for the part-time fishers. Most of the people in Lake Kariba are either directly or indirectly involved in fishing activities as their main economic stay, full-time activity, or part-time employment. Six types of fishing gear were identified; these included cast nets, drag nets, seine nets, traps, hook and line, and baskets locally known as miono.

5.4.2 Social Amenities

The study showed that 34.7% of the fishers still use water from the lake for home consumption, such as drinking and cleaning, while 14.93% indicated having access to and being able to use borehole water. Only 29% confirmed having pit latrines, but 11.28% of the respondents in the study area indicated that they had no access to any form of a toilet. Schooling is problematic too; although more than 65% of the fishing villages have primary schools within a distance of 0 to 5 km, the distance to a secondary school remains a challenge. The captured data show that more than 70% of the secondary schools can only be accessed at a distance greater than 5 km

(FGDs). With regard to health services, 44.7% of the fishing villages fell within a distance of up to 5 km from the nearest clinic; these were mainly from strata IV and II. In stratum I, 40% of the fishing villages were more than 10 km from the nearest clinic.

5.4.3 Economic Status of Fishers

According to the study, the fishers in Lake Kariba dispose of their fish catches on reaching the landing sites. About 74% of the daily fish catches were sold to local consumers and residents, while the remainder (23%) were for consumption. About 3% of the remainder of the fish caught were exchanged for other commodities, such as maize meal, cooking oil, and second-hand clothes. Most of the fishers indicated that the sale of fresh fish to local customers fetched a high price and minimised marketing costs. The average price of fish sold was valued at USD 2.15 per kg in 2021, a price that is over 90% higher than the price of USD 0.960 per kg recorded in the 2011 frame survey. The price of fish depends on the quality, weight, species, and seasonality. The key informants claimed that income from fish produce had fallen owing to seasonal fluctuations and the decline in the valuable *Oreochromis* fish species. The fish catches are perceived to have gradually declined over the last decade, but the increased market values for the fish have not kept pace with this decline. The finding of the study indicated that most of the fishers in the lake (44%) earn about USD 150 per month, while 5% of them earn more than USD 600 a month (Table 5.3).

Table 2.3 Household monthly income of (fishers).

Variable		Frequency (*n* = 300)	Percent %
Monthly household income	<USD 160	130	43.3%
	USD 161–230	60	20%
	USD 231–330	45	15%
	USD 331–430	26	8.6%
	USD 431–530	24	8%
	USD 531–630	15	5%
	USD 630>	-	-
Current income compared to 10 years ago	Better	32	10.6%
	Stable	38	12.6%
	Decreased	230	76.6%

According to the key informants, the fish prices kept on increasing every year. However, the overall fish production trend shows that the fish production has remained relatively stable. A curve fit estimation regression test carried out revealed that there had been no significant difference in the fish production trends over the past 13 years (R2 Linear = 0.119, p = 0.248) (Figure 5.2).

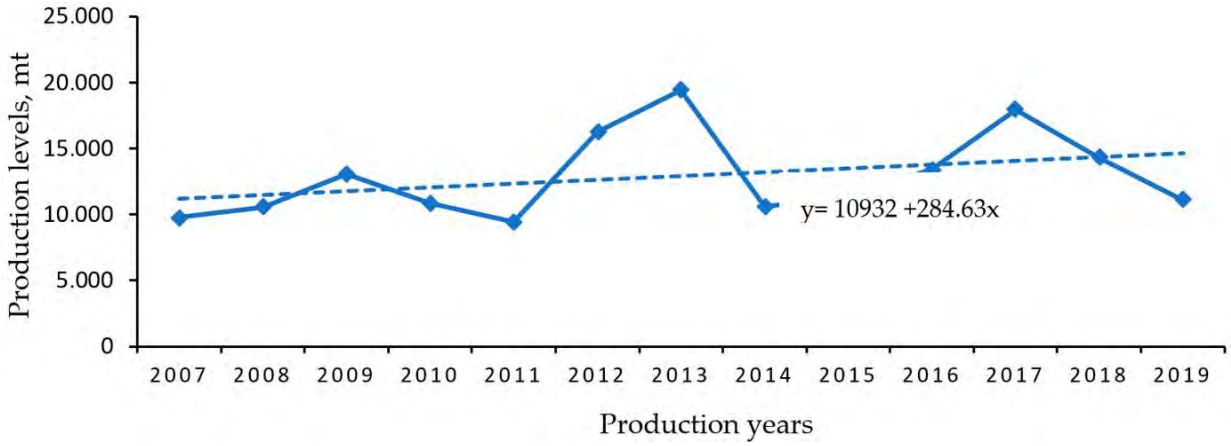

Figure 5.2 Fish production trend (tonnes per annum) in Lake Kariba between 2007 and 2019. Source:(DOF, 2020).

Although the overall fish production in Lake Kariba has remained stable, according to the focus group discussions, the small-scale fishers for all categories have not produced the anticipated levels of economic gains from fishing, but fishing has notably helped those referred to here as full-time fishers in sustaining their livelihoods. The part-time fishers have been prevented from sinking into the vicious circle of poverty as their fishing proceeds frequently supplement wages earned from labouring. Small-scale fisheries provide a more reliable source of income for fishers than the wages derived from non-fishing activities.

5.4.4 Social Conditions and Fisher Vulnerability

Our findings show that the fishers are educationally, socially, and economically disadvantaged. They have inadequate access to financial services, and their families face numerous challenges, the most common among them being low income. Irrespective of the different categories, most of the fishers reported that their income from fish sales was spent on purchasing essential commodities, such as clothes, food, and household maintenance. Credit institutions are very limited in the entire fishing community, with only 20% of fishers able to access financial aid in the form of microcredit from government-funded institutions, with interest rates ranging between 25% and 38% per year. Food insecurity in the fishery was observed to be a common problem which the fishers attributed to low income and the high food prices experienced in the

recent past. According to the key informants, the prices of food over the past five years had increased by 60%. Most of the fishers interviewed (80%) stated that their household could no longer afford three meals a day, and that they had reduced the number of meals, sometimes swapping to undesirable but inexpensive food. The proportions of the fish catch consumed at the household level varied; for example, the full-time fishers consumed a much lower proportion (10%) of their fish catch, preferring to sell three-quarters of their catch and buy cheaper foodstuff. Generally, the fishers consume most of their fish catch (85%) and trade the remainder, particularly the large fish, which are perceived to fetch a relatively much higher price. The seasonal fishers tend to consume more than half their fish catch.

The vulnerability context has subjected fishers to low income due to the seasonal price fluctuation of fish catches. Forty percent of the respondents revealed that the fishers were vulnerable to sickness and diseases, especially during the rainy season. The fishers suffer from cholera, dysentery, diarrhoea, malnutrition, and malaria. The study observed that most of the fishing villages rely on water directly from the lake for washing clothes, drinking, and bathing. Other challenges raised by fishers included lack of capital (50%), low income (43%), and user conflicts (44%). The catches were said to be much better in summer than any other season of the year, and most of the respondents indicated that they harvested very low quantities of fish in winter, which gave them a paltry return for most of their daily expenditure (Table 5.3). Further responses from all the categories of fishers revealed that user conflict among the various users of the fishery was an increasing problem arising from conflicting interest over access to fishing grounds. These user conflicts occur between inland aquaculture farmers, semi-industrial Kapenta fishers, anglers, and small-scale fishers over access to fishing grounds. Conflict often intensifies when small-scale fishers are prohibited from the fishing grounds where they have fished for subsistence over decades.

5.4.5 Environmental Conditions of the Fishery

According to the study, most of the experienced fishers and experts expressed concern over the decline in the fish species of economic value, such as *Oreochromis mortimeri*. About 70% of the respondents reported that overfishing was among the most important threats to the fisheries. The chi-square test that was performed showed a statistically significant difference in the selected indicators of the fishing efforts between 2006 and 2011. (X2 = 180.14, p-value = < 0.00001) (Table 5.4). Generally, most of the fishery areas in the country have recorded an increase in fishing effort indicators.

Table 5.4 Differences in rate of increase in selected indicators between 2006 and 2011.

Increase in the Last 5 Years	**2006**	**2011**
Total number of fishermen	2804	4653
Total number of boats	2431	3451
Total number of nets	19,500	26,769

X^2 = 180.14, *p*-value = <0.00001. [Source: adopted and modified from the LKFRI (Lake Kariba Fisheries Research Institute 2011]

According to the study, 71% of the respondents identified land-use practice (e.g., subsistence agriculture and human settlements) among the other threats to the fishery (Figure 5.3). About 76% of the respondents indicated that the operation of the hydroelectric power station could affect fish productivity by altering the distribution and migration pattern. Only 66% of the fishers identified poor legislation as a threat to the fisheries. A further environmental threat identified by the respondents was the deterioration in the water quality due to pollution (Figure 5.3). Field observation revealed that the waste from human activities such as gardening and subsistence agriculture, and excessive loads of nutrients from household waste and municipal sewage are disposed directly into the lake. The main problem is related to the increased nutrient input from household waste and the municipal sewage load directly entering

the lake. This was observed to be a common problem, especially in strata IV and II. According to the key informants, organic matter, solid waste, and nutrients that leach into the lake were a result of land-use practices and urbanisation (Figure 5.3). The introduction of invasive fish species was identified as one of the emerging environmental threats to Lake Kariba (Figure 5.3).

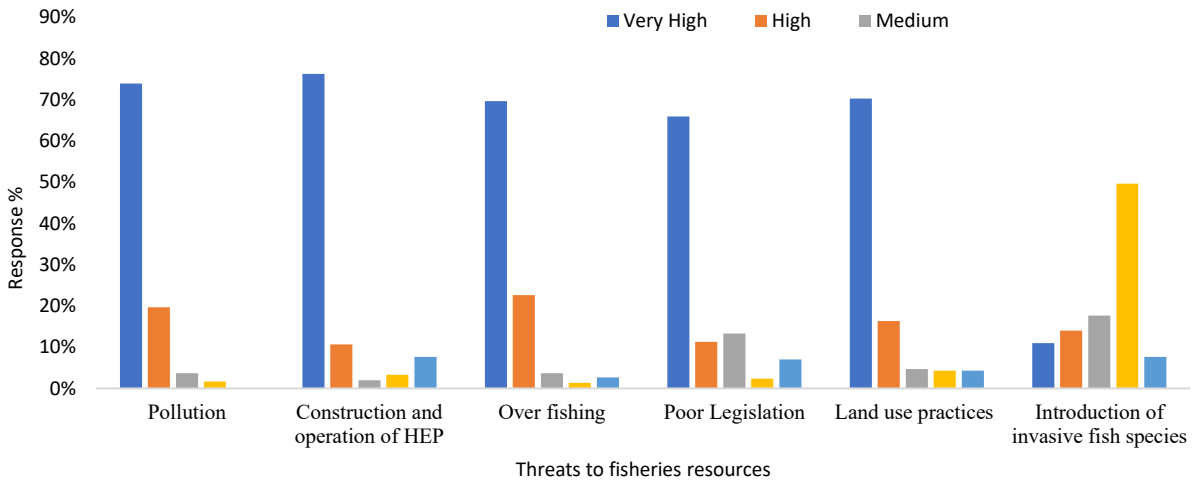

Figure 5.3 Factors perceived by fishers as threats to fisheries resources in Lake Kariba

5.4.6 Livelihood Strategies

Fishing appears to be the most important source of livelihoods across the four strata, with 82% of the respondents undertaking this activity, while 21% practise both fishing and fish farming activities. The field observation confirmed these livelihood strategies. Vegetable gardening and small livestock production are some of the livelihood adaptation strategies observed in the study area. The crops grown include millet, sorghum, and maize. Other forms of livelihood strategies observed include activities such as running a shop, selling airtime, and fish processing, which was mostly practised by women. Generally, most of respondents in Lake Kariba were entirely dependent on fishing. Reducing the number of meals and substituting with less favoured but inexpensive food to save scarce resources were common adaptation strategies. The study further revealed that most fishers have adapted by increasing fishing effort

using multiple fishing nets. The full-time fishers were reported as selling most of their fish catch in order to buy less expensive foodstuffs. According to key informants, some of the fishers from Zambia have opted to cross into the Zimbabwean waters for fishing expeditions, where fish catches are reported to be abundant.

5.5 Discussion

In the years between 1960 and 1980, the Lake Kariba fishery was robust and rich in fishery biodiversity (Musando, 1996; Karenge & Kolding, 1994). In recent decades, natural and anthropogenic activities have affected the fishery (Mhlanga, 2009; Nyirenda, 2017). Although the statistical data on fish production from Lake Kariba have not shown a significant decline in the overall fish production over the past 13 years, a decline in both the numbers and the size of the *Oreochromis* fish species has been observed and reported by various authors (Maulu & Musuka, 2018; Chifamba & Mauru, 2017; Tweddle et al., 2015), as has a general decline in fish species of high economic value (*Oreochromis spp*) (Chifamba & Mauru, 2017). This trend suggests that over-exploitation of a fishery may not only be characterised by a decline in overall production, but also by shifts in the species composition and the extinction of individual fish species (Chifamba & Mauru, 2017). These changes have raised concerns about fish depletion among the various stakeholders along the Agri-fisheries value chain (Helfman, 2007; Tweddle et al., 2015). Most of the key informants stated that activities such as overfishing and land-use practice have caused considerable ecological concern about the decline in both the water quality and the fisheries. It is generally accepted that the rampant use of destructive fishing gear and the increased fishing efforts are indications of overfishing (Helfman, 2007). The analysis of the frame survey data for Lake Kariba shows that there is a statistically significant increase in the fishing efforts, raising concerns about overfishing. The fishers alleged that small-scale fishing was not destructive to the fishery; they argued that fishing had been going on for decades. However, some of the key informants acknowledged that small-scale fishing

has the potential to affect the fishery negatively when destructive fishing gear and methods are used; for instance, the use of draw nets (chasing fish into a gillnet by beating the water) have a negative impact on fish spawning and mouth brooders (Weyl et al., 2005).

The distribution and the composition of key fish species have shifted over time; this is thought to be due to multiple interactive stressors such as overfishing and habitat destruction (Karenge & Kolding, 1994). The increase in the fishing efforts and the targeting of larger and more valuable fish species can lead to more serious ecological disturbances that can affect the biological diversity of the fisheries in what is known as 'fishing down the food web', which involves harvesting relatively larger-sized multi-species fish assemblages and replacing them mainly with small-sized ones at low trophic levels (Chifamba & Mauru, 2017; Helfman, 2007). The loss of these valuable fish species has the potential to affect the regeneration processes of the fisheries' biodiversity as rich fish species communities are known to promote a more stable environment (Helfman, 2007; Chifamba & Mauru, 2017). Even though the fishers on Lake Kariba acknowledge the progressive increase in the fishing efforts, they argue that they have limited livelihood options. This underscores the need for management strategies that are based on a broad human development perspective through the enhancement of alternative livelihoods, such as aquaculture development and beekeeping, among others (Ahmed et al., 2013).

The study identified water pollution as a serious emerging environmental challenge caused by deforestation, mining activities, and subsistence agriculture along the shoreline. These activities have negatively affected the fishery, leading to environmental problems related to water quality, habitat loss, and sedimentation, especially in strata II and IV, where the fishery has experienced rapid urbanisation. Coal mining and agriculture activities along the shoreline have further contributed to the pollution (Magadza, 2010). Organic matter, solid waste, and other forms of nutrients leach into the lake; these substances have the potential to cause significant environmental stress in the fishery and in the oxygen balance of the aquatic

environment, with cascading effects on fish productivity and livelihoods (Smith et al., 2011). This sustainability challenge can disrupt and alter the composition of fish species, including benthos and planktons, and affect fish productivity (Smith et al., 2011). Field observation shows that inland aquaculture is growing fast in Lake Kariba and is generally viewed as an efficient way of scaling up fish productivity and bridging the fish deficit in Zambia, which has remained at 9 kg per capita for over a decade now (Tran et al., 2019). Despite this potential, the sector has suffered from a lack of quality support and a clear regulatory framework to guide management perspective (Kefi & Mofya-Mukuka, 2015). In some areas, it has even led to environmental and social problems, due to a lack of environmental understanding of the linkages between the supporting environment and the cultivation. The commercialisation of the Lake Kariba fishery for inland aquaculture development, especially in stratum IV, has contributed to the loss of productive habitat and reduced the water area for nursery and fish spawning grounds. This development has higher risks in that it may introduce fish diseases such as epizootic ulcerative syndrome (EUS) and the Tilapia Lake virus, among others (Madzudzo et al., 2014).

The development of specific regulations to govern this industry, especially those related to environmental impact and management, requires further environmental risk assessment and monitoring, which are currently not available for Lake Kariba (Kefi & Mofya-Mukuka, 2015; Madzudzo et al., 2014). This development exerts pressure on the limited fishing grounds, with serious implications for the policy reforms in the fisheries and aquaculture sector in Zambia. Our observations on the aspect of the engineering works and operational activities of the hydroelectric power plant on the Lake Kariba fishery revealed negative effects on the hydrological regimes, with fragmentation of the adjacent biodiversity. This scenario has negatively affected fish distribution, with migratory fish species, such as *Label altivelis,* reportedly being affected. A further environmental challenge reported was the introduction of

alien invasive fish species such crayfish (*Cherax quadricarinatus*). The latter is reported to have been accidently introduced into Lake Kariba from fish farm escapees around the 1990s. By 2009, crayfish were widely distributed and had a fully established population throughout the lake. The introduction of the crayfish into Lake Kariba and on the African continent acts as a nuisance, destroying fish eggs, nests, and habitats for spawning fish (Madzivanzira et al., 2022; Situmbeko et al., 2019). Most fishermen have complained and reported anecdotally the manner in which crayfish affect their catches. Some of the potential effects include the transfer of diseases and parasites; competition with other crustacea; predation on larvae and fish eggs; and habitat destruction due to functional responses such as burrowing habits and macrophyte cropping. Crayfish can cause considerable damage to fishing gear, resulting in increased servicing costs (Ogutu-Ohwayo & Balirwa 2006). The entanglement of crayfish in gillnets has often resulted in ghost fishing gear as the fishers opt to abandon their nets; the partial eating of fish trapped in static gillnets is also a source of concern among fishers in Lake Kariba (Madzivanzira et al., 2022). There has been no serious intervention from the relevant authorities, or biosafety measures to control the spread and invasion of invasive fish species in Lake Kariba (Kefi & Mofya-Mukuka, 2015). Furthermore, the displacement and disappearance of the abundant Kariba bream (*Oreochromis mortimeri*) in Lake Kariba has been attributed to the accidental introduction of the invasive Nile tilapia (*Oreochromis niloticus*) in the 1980s, perpetuating interspecific competition for food and space, agonistic interaction, and intraguild predation (Nyirenda 2017; Darwall et al., 2020).

While the negative impact of the invasive *Oreochromis niloticus* has been widely documented in the literature (Nyirenda, 2017; Situmbeko et al., 2019; Madzivanzira et al., 2022), the positive aspect of this fish species as an efficient feed converter has made it acceptable as the most important fish species harvested in Lake Kariba, comprising 50% of the total catch (Nyirenda, 2017). *Oreochromis niloticus* precipitated the development of the

aquaculture sector and is now among the most popular kinds of table fish in Zambia (Kaminskia et al., 2018). It ranks as the most productive commercially valuable fish species in both capture fisheries and inland aquaculture in Lake Kariba (Nyirenda, 2017; Kaminskia et al., 2018). This, together with the successful establishment of *Limnothrissa miodon*, has put Lake Kariba among the best examples of the successful utilisation of introduced fish species for stock enhancement (Weyl et al., 2010). However, more studies are required to assess the environmental challenges associated with the introduction of *Oreochromis niloticus* and other invasive fish species, such as *Limnothrissa miodon*. In addition to the presence of invasive animal species, invasive plant species such as water hyacinth have established in Lake Kariba, especially in areas around the dam wall (Tumbare, 2008). The establishment of this invasive plant species has the potential to condense open areas for fishing, interfere with fishing expeditions, and affect the movement of clogged waterways. The abundance of water hyacinth can reduce the dissolved oxygen content, which may have an impact on fisheries biodiversity (Weyl et al., 2010; Schindler et al., 2010). The present study has further shown that poor legislation has constrained management efforts to enhance fisheries productivity in Lake Kariba. The fisheries policy direction in Zambia currently aims at maximising fish production to meet the urban fish demand and employment opportunities for rural communities (Nyikahadzoi et al., 2017). However, the regulations do not limit the amount of fishing gear that an individual fisher can use, and the fishery still operates in an open-access form (Nyikahadzoi et al., 2017).

The open-access form raises concerns as uncapped access can lead to intensive fishing with severe impacts on fish breeding (Ahmed et al., 2013; Coll et al., 2006). If the current socio-economic and environmental condition in Lake Kariba remains unchecked, it could lead to what Hardin (1968), described as the ‘tragedy of the commons’, where unfettered access to common resources, such as littoral fisheries, leads to unchecked exploitation and cascades into deep and wide environmental degradation (Hardin, 1968; Pomeroy et al., 2001).

The Fisheries Act No. 22 of 2011 appears to be comprehensive and provides good regulations for the management of the fisheries. However, it is characterised by the attributes of a centralised management system that undermines the active participation of the local resource users in fisheries management. The Fisheries Act empowers the Fisheries Directorate to initiate and lead the local management plans that are often imposed (Kapembwa et al., 2021). Although the Fisheries Act provides for community participation in the management of fisheries resources in Lake Kariba, the level of participation is moderately practised in the sense that roles are not well defined, despite the skill, experience, and environmental knowledge fishers bring to participatory management (Hara, 2011). This has created a knowledge gap in how indigenous knowledge can serve as a foundation from which to extrapolate specific interventions that are contextual in nature (Aswani & Hamilton, 2004). Several studies have shown that active community participation in the management of natural resources is the context in which to overcome environmental challenges and a cost-effective method of resource management (Clay & Olson, 2008; Jentoft, 2000; Berkes, 2003), because the government is often too overwhelmed to reach out to highly scattered areas for monitoring and enforcement of fisheries regulations (Haambiya et al., 2016).

The discussions with the key informants revealed that the fishermen on Lake Kariba are often engaged in assisting the government officials to collect statistical data on fish (Nyikahadzoi et al., 2017). The scenario underscores the need to have a stronger institutional arrangement that provides for real authority for community participation in the management of their resources to legitimise stakeholder participation (Malasha, 2008; Hara & Njaya, 2016). In light of the socio-economic and environmental challenges faced by the small-scale fishers on Lake Kariba, adaptation strategies exist among the fishers; some fishing households seem to diversify their livelihoods towards subsistence agriculture and livestock production, while others remain as fishers; some increase fishing efforts, while others are engaged in casual duties

such as selling basic commodities in marketplaces. However, these adaptation strategies do not provide a stable source of income (Kapembwa et al., 2021). Agriculture may be a stronger alternative livelihood, but the topography and climatic conditions of the area appear to favour very few crops, such as drought resistance crops (Ndhlovu et al., 2017). The rainfall season is short and low (less than 500 m) due to climatic changes (Folke et al., 2005).

These climatic changes are likely to have social, economic, and environmental impacts on fisheries and agriculture, with cascading implications for livelihoods, food security, and income generation. Ndebele-Murisa et al. (2011) indicated that temperatures around the Lake Kariba catchment area have been rising faster than the IPCC forecasts for Southern Africa. These environmental problems have been exacerbated by the impact of land tenure transformations which occurred in the 1950s, before and after the dam wall construction (Mhlanga, 2009). The construction of the dam wall in the middle of the Zambezi River, forming what is today known as Lake Kariba, resulted in the mass displacement of over 57,000 indigenous Tonga/Korekore ethnic people (Mhlanga, 2009). Their resettlement was forced and badly planned (Kapembwa et al., 2021; Etiegnia et al., 2019), and those displaced communities are still suffering from the challenges associated with this resettlement that took place in the late 1950s (Magadza, 2010). The state displaced them from the banks of the fertile Zambezi River, where they used to have two seasons of crop production and access to fisheries throughout the year. During this period, three-quarters of the local communities were forcibly relocated to a higher and drier arid land, in some cases where there was competition for space with the wildlife animals in adjacent game parks (Ndhlovu et al., 2017). The consequence of the forced relocation was the loss of a more stable livelihood opportunity. A detailed study of this aspect may be required to draw lessons on the implications of land tenure transformation for livelihoods and freshwater ecosystems. Based on the results of this study, it is apparent that the current environmental pressures may deepen if not adequately addressed, with long-term

effects on fisheries biodiversity, and adverse impacts on food security (Kapembwa et al., 2021). The problem exposes fishers to nutritional food insecurity since most of the people living along the shoreline are highly dependent on the lake for sustenance (Etiegnia et al., 2019).

5.6 Prognosis for Sustainable Fisheries Management

Despite the existence of two distinct fisheries in Lake Kariba, the living conditions of the fishers is vulnerable to fish decline and the fragile condition of the lake. The living conditions and the socio-economic status of the small-scale fishers has remained poor and subject to pervasive poverty. A major challenge is that the context of the vulnerability of the fishers is not within their control because of government interventions that are often not inclusive of local participation (Chama & Mwitwa, 2020). Therefore, it is very important to devise remedial measures aimed at reducing the level of vulnerability and enhancing resilience in the management of the fishery (Jentoft, 2000; Ostrom, 2009). To enhance the livelihoods of the small-scale fishers and to reduce the impact of fishing pressure on the lake, the management strategies must be able to address the various socio-economic and environmental challenges affecting the fishing communities and the lake upon which their livelihoods depends (Irvine et al., 2019). The idea of sustainable fisheries management provides for various linkages across the multiple social, economic, and ecological facets of the fishery systems (Valbo-Jørgensen and Thompson, 2007). Mutual linkages among these systems may create a sense of responsibility for community participation and may create institutional responsibility (Folke et al., 2005). A social-ecological approach which emphasises the human–environment interaction is needed. Ahmed (Ahmed et al., 2013) proposed a management system that links various social, economic, and ecological aspects to balance societal needs and objectives. The system highlights a range of ecosystem benefits and services that communities derive from the environment and reconciles the feedback loop relationship of human economics and the ecosystem (Ahmed et al., 2013). We recommend such a management system for Lake Kariba

(Figure 5.4). The economic aspects in this case include fish marketing, fishing costs, income, and employment. The social aspects refer to the livelihoods of the fishers, the cultural factors, and the social benefits. The ecological consideration includes the condition of the lake over the long term, including siltation, pollution, and the conservation of fisheries biodiversity.

A comprehensive understanding of how these aspects interact in time and space are essential and must be given consideration (Ogawa & Reyes, 2021). The connections existing between the ecological, social, and economic aspects are shown in Figure 5.4, and analysing them in this fashion clearly illustrates the influence and importance of the ecological-economic, socio-ecological, and socio-economic links (Jentoft, 2000). The knowledge about this interaction is critical for the conservation of the ecosystem processes that support the fisheries, and for the refinement of the social mechanisms for the governance and equal distribution of the economic benefits at different scales (Jentoft, 2000). A compressive social and ecological system can withstand the negative shocks and subsequently lessen the vulnerability of the fishers to environmental challenges. (Berkes, 2003; Garcia & Charles, 2008). This approach constitutes a concept which emphasises the human-environment interactions in the management of fisheries (Lam et al., 2012). Fishing is an ancient occupation and a source of food security whose foundation is rooted in human and natural linkages from which economic benefits such as income and employment are derived (Berkes, 2003). The socio-ecological resilience of a fishery is, to a large extent, dependent on the livelihood security of the users (Berkes, 2003). Ostrom (2009) identified four characteristics of a social and ecological system: a resource system (e.g., fishery), a resource unit (fish), the users (fishers), and the governance systems and other interested stakeholders.

The interaction of these systems at different levels can be used to produce positive results (Ostrom, 2009). In developing an efficient fisheries management structure, it is crucial to secure a balance between the environmental, social, and economic benefits and costs to meet

the human needs for both present and future generations (Etiegnia et al., 2019). Such interventions guarantee sustainable natural resource utilisation, such as fisheries, and enhance the livelihoods of dependent communities (Folke et al., 2005). Three major components that can be used to design a sustainable fisheries management plan have been identified in this study: (i) institutional collaboration, (ii) laws and policies, and (iii) active community participation (Table 5.5).

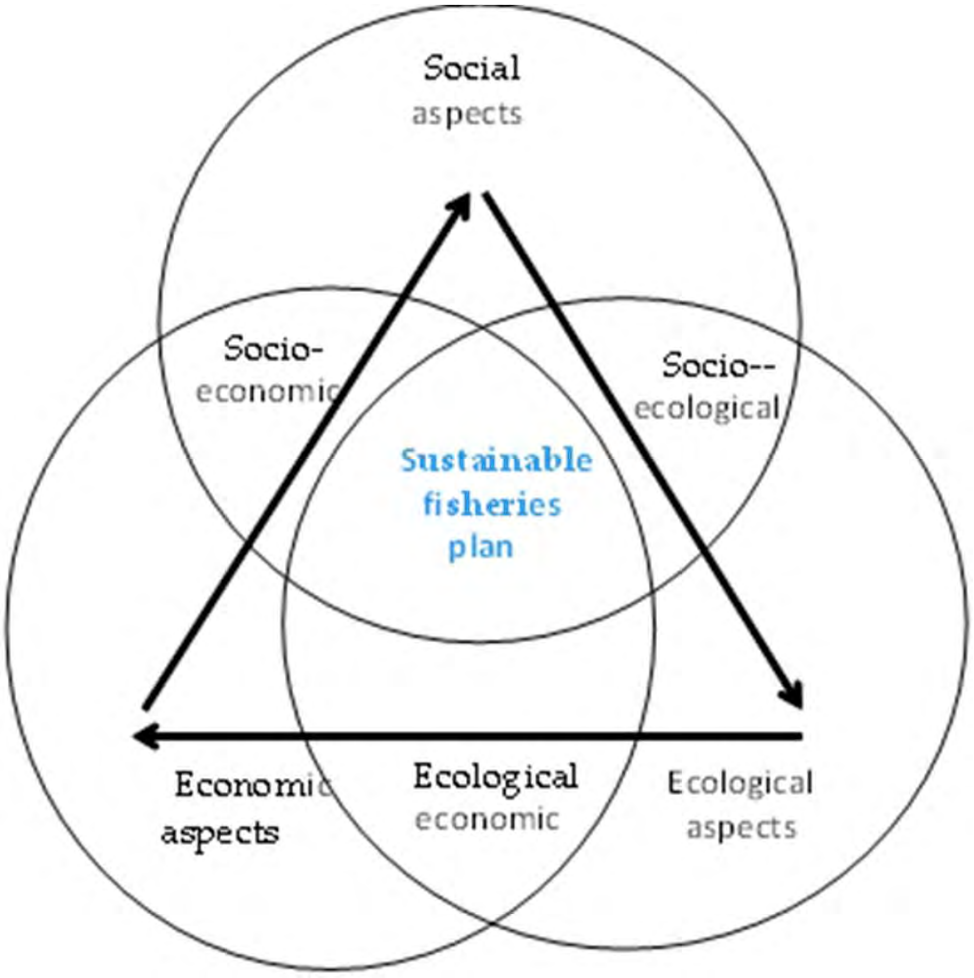

Figure 5.4 A systematic diagram for sustainable fisheries management, illustrating the need to evaluate and account for socio-ecological, ecological-economic and socio-economic interaction in fisheries management

[Source: adopted and modified from Ahmed et al., 2013, and FAO, 1995].

Table 5.5 Key strategies for sustainable fisheries management

Components	Examples
Institutions	o Support systems by both government and private institutions such as NGOs and civil society organisations o Training services for fishers to enhance capacity and willingness to actively participate in fisheries management o Institute regular research and monitoring activities for lake management
Laws and policies	o Pertinent government laws, policies and implementation of fisheries regulations (regulate overfishing and prohibit bad fishing practices) o Conservation of fisheries biodiversity by way of establishing protected areas such as sanctuaries o Strengthen environmental protection activities to control pollution and siltation
Community participation	o Community participation through establishment of fishing village committees o Active fisher community participation for fisheries resource utilization and management o Community awareness programmes for environmental protection and maintenance of lake ecosystems

[Source: Adopted and modified from Ahmed et al. (2013) and FAO (1995)].

The aforementioned aspects will strengthen the capacities of both the local and the national institutions and create partnerships across the institutions of the riparian countries, with a focus on scaling up alternative livelihoods. Furthermore, educational efforts can show the local and international value of fisheries for food security and biodiversity conservation, especially of the commercially valuable fish species (FAO, 2022; Aura et al., 2018). Challenges of the freshwater fisheries in this study are attributed to the environmental degradation, which is due to human activities (Craig et al., 2004; Baird, 2006). We suggest that public institutions, civil society organisations, and other interested stakeholders jointly working together would

aid the protection of the lake environment. The sharing of experience and the exchange of ideas, training, and technical support would generate important knowledge, which is essential for management (Berke et al., 2000). The symptoms of the decline in fish resources in Lake Kariba are attributed to multiple factors, but weak policy legislation is, however, very apparent. It is a situation that has been largely characterised by a moderate co-management system of governance (Haambiya et al., 2016). Kapembwa (et al., 2021), observed that the set-up was so because responsibility for the fisheries management was carried out by government authorities through local authorities instead of the fishing community, thereby defeating the original expectation which was to decentralise the fisheries management. Therefore, the enactment of policies aimed at providing guidelines for resource users' roles under co-management would enhance the conservation measures for fisheries biodiversity (Valbo-Jørgensen & Thompson 2007), so helping to further conserve pure brood stock to scale up aquaculture production, which has currently put Zambia in the lead as the largest producer of farmed fish in southern Africa (Tran et al., 2019) and may have positive benefits for the fisher communities (Chowdhury & Yakupitiyage, 2000; Utete et al., 2018).

Active community participation has been identified as being among the best strategies for achieving sustainable resource management (Chama & Mwitwa, 2020). As a homogenous entity, community participation is considered to be a viable institution for effective collaborative resource management (Weyl et al., 2010). The assumption is that if community participation in conservation is effective, the benefits accrued from conservation will create a sense of responsibility and ownership for the community members so they can become good stewards of the resources (Marshall, 1995; Allan, 2005; Ogutu-Ohwayo et al., 2016). We therefore suggest that a stronger community-based fisheries management structure could be a significant innovation in addressing the aforementioned socio-economic and environmental challenges facing the small-scale fishers in Lake Kariba. This will require a policy direction to

provide their roles and responsibilities to ensure efficiency. It will furthermore help to accelerate the attainment of the United Nations Sustainable Development Goal number 17, which recognises the role of partnerships for sustainable development (Berg et al., 1996; Ogutu-Ohwayo, et al., 2016). It is grounded on the hypothesis that strong partnerships will activate a broad range of stakeholders in the acquisition of knowledge, experience, technology, and resources towards attaining the global agenda. The positive outcome of such a strong partnership is the sustainable conservation of biodiversity to alleviate poverty through the responsible fisheries management of the inland fisheries (FAO, 1995).

5.7 Conclusion

The focus of this study was to understand the socio-economic conditions of small-scale fishers and to identify the environmental threats that may have negative effects on fisheries abundance and the livelihoods of the fishers in Lake Kariba, Zambia. The results obtained showed that the communities around Lake Kariba depend on fisheries as a source of income and employment. While the overall fish production has not significantly declined in the past 13 years, fish species of high economic value, such as *Oreochromis spp.,* have declined. The fishery is exposed to wide scale environmental threats, such as pollution and overfishing. This trend has negatively affected the livelihoods of the small-scale fishers. The prognosis for sustainable fisheries management in Lake Kariba will depend on the possibility of reconciling the various social, economic, and ecological aspects of the fishery. Such interventions must ensure that the proceeds of enhanced management are shared equitably among the resource users to maintain the long-term stability of their resources.

The fishers in Lake Kariba are vulnerable to resource degradation cascading into the loss of social, economic, and ecological proceeds that can be attained through responsible fisheries. To devise a sustainable fisheries management plan, the interacting social, economic,

and ecological facets must be considered. Consequently, any effective management intervention must aim at regulating the utilisation of the resources to ensure sustainable use. Hence, a combination of socio-economic, ecological-economic, and socio-ecological approaches to fisheries governance must be incorporated into the management plans. Effective enforcement of legal legislation and stronger institutional collaboration among the stakeholders in the riparian states, as well as active community participation in the governance of the resources, will be vital in securing responsible fisheries on Lake Kariba. Finally, actual studies on the ecological experiments and other socio-cultural issues are required for further policy recommendation on the topic of study.

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Chapter 6

Conclusion and recommendations -Towards a policy Brief

6.1 Introduction

The sixth's chapter of this thesis is a policy brief; it highlights the major findings of the current study, policy and theoretical implications, conclusions and recommendations. The policy brief contributes to knowledge for sustainable fisheries management and governance. The overall aim of the study which led to the production of this document was to evaluate the nature of the small-scale fishing practices on Lake Kariba, examine their socio-economic conditions and identify the environmental threats that may have negative impacts on fisheries biodiversity and the livelihoods. In addition, the study aimed to assess how small-scale fishers have adapted to the socio-economic and environmental changes over time and to suggest possible interventions to protect the fishery from further deterioration.

Figure 6.1 Small-scale fish traders in KAZA-TFCA

Inland fisheries in southern Africa play a key role in poverty alleviation to drive socio-economic development (de Graaf & Garibaldi, 2014; Ndhlovu et al., 2020). The contribution of the fisheries sector is estimated at approximately 3.5% of regional gross domestic product (GDP). In addition, it generates employment opportunities for about 2.3 million people and

provides some of the best examples of gender-inclusive value chains in the region (see Figure 6.1).

While the potential for inland fisheries to contribute to Africa's food and nutrition security is of great importance, the prospects of this natural resource remain uncertain (Chan et al., 2019). The present study has shown that Inland capture fisheries in the region are constrained by poor legistration and several anthropogenic factors including habitat destruction, water pollution, hydro-power activities, introduction of invasive fish species, user competition for freshwater environments, such as agricultural development and the development of inland aquaculture. These anthropogenic stressors are a double loss of biological diversity, and the loss of a natural resource on which vulnerable people depend. This sustainability challenge subsequently exposes the livelihoods of fishers to vulnerability (MEA, 2005; Yuerlita, 2013). The current study has further shown that the nature of small-scale fisheries exhibits diverse socio-economic characteristics including crop agriculture and small livestock, with homogeneity fishing practices. Understanding the nature of small-scale fishers and how fisher communities in Lake Kariba respond and adapt to various socio- economic and environmental changes can provide baseline information necessary for effective policy interventions (Muringai et al., 2020). The current fisheries management practices based on classical interventions such as gear and effort restrictions have largely failed to contain the many challenges faced by small-scale fisheries. These challenges include resolving user conflicts, preventing fish stock depletion, habitat restoration, and preventing social disruption (Mhlanga, 2009; Mosepele & Kolowole, 2017),

Local people are unable to respond to these fast-developing pressures; the fisher communities are often disempowered to emerging stronger external stakeholders, including foreign entities practicing inland aquaculture; the lake exists as an open-access space (Mhlanga, 2009). Given the importance of fisheries resources to socio-economic development of the

region and the magnitude of threats at play, stronger institutional arrangements of governance are required to deal with the emerging challenges (Weyl et al., 2007; Weyl et al., 2020).

Key messages

- Inland capture fisheries on Lake Kariba have suffered multiple interactive factors including overfishing, water pollution, encroachment and climate change. These have caused ecological disturbances and threatened the future of small-scale fisheries.
- The question of how fishers have adapted to these challenges has raised concerns among various actors along the value chain.
- Fishing in Lake Kariba remains the most valuable economic activity among the local residents, largely due to limited alternative sources of livelihood.
- In order to sustain the contribution of Lake Kariba fishery for food and nutritional security in the region, it is essentially important to design responsible interventions, such as:
    - Establishing stronger policies, institutions and educational systems that will show the value of fish for food security and biodiversity conservation among the riparian countries.
    - The establishment of an effective transboundary fisheries management system across the entire Kavango-Zambezi River catchment, including Lake Kariba.
    - Establishing a multi-stakeholder's platform for various value-chain actors that sufficiently integrates local knowledge as part of inclusive joint management practices.

6.2 Materials and Methods

This policy brief is based on the key results of the study conducted in Lake Kariba among the local fishing communities. Secondary data source were obtained from various sources, such as

journal articles obtained through internet search, grey literature, and official reports from the Department of Fisheries in Zambia. This was coupled with the researcher's experience as a fisheries research officer for Lake Kariba from 2010 to 2017. The study used a mixed method approach to obtain both qualitative and quantitative information necessary for data analysis. Focus group discussions were held with experienced fishers and fish traders in the study area to verify information obtained from secondary data sources, while key informant interviews were conducted with government officials from the Department of Fisheries (DOF), local authorities, fisher associations and civil society organizations involved in promoting the well-being of fishers in the area. A household questionnaire survey was administered using a proportional quota sampling technique in every sampled fishing village. Participant observation was among the data collection techniques used during the study.

6.3 Study findings and synthesis

Lake Kariba is an artificially man-made lake composed of two distinct fisheries: the small, pelagic, semi-commercial, single-species offshore fishery, and the small-scale, multi-species inshore fishery (Kolding et al., 2002).

Figure 6 6.2 Small-scale fisheries activities in Lake Kariba

The nature of small-scale fishers existing in Lake Kariba comprises of full-time, part-time, and seasonal fishers. These are characterised by various species assemblages with multiple fishing

gears. Current evidence from the study shows that overall, small-scale fisheries remain a major source of employment and food security for lacustrine communities on Lake Kariba and many other people along the Agri-fisheries value chain (Figure 6.1).

6.4 The context of fisheries vulnerability in Lake Kariba

Despite fisheries playing a critical role in livelihoods of the majority fishing-dependent communities in Lake Kariba, these are often sidelined in the fisheries management decision-making processes. This situation has slowly led to loss of access rights and control of an indigenous resource by local inhabitants. This scenario raises food security concerns and orchestrates vulnerability among small-scale fishers in the area. Over the past three decades, Lake Kariba has experienced a major shift in tenure transformation to support various economic interests at the expense of the indigenous people who have largely lost ownership over their precious resource. New and stronger user groups have emerged and developed larger enterprise displacing the indigenous people. At the centre of this transformation are issues of sustainability of the aquatic environment resulting in a wide range of environmental threats and declining trends in fish species of socio-economic value. The synergistic impact of these threats has manifested in a double loss of fisheries biodiversity and a natural resource on which vulnerable communities derive their livelihoods (Tweddle et al., 2015; Chifamba & Mauru, 2017). These findings concur with several other studies which shows that inland fisheries in most developing countries are marginalized in planning and development processes (Mosepela and Kolawole, 2017; Muringai, et al., 2020). These problems coupled with depleted resources and poverty makes inland small-scale fishers more vulnerable.

Furthermore, the study has revealed that the utilisation and accessibility to fishing by local resource users in Lake Kariba is increasingly mired by multiple competing users (Figure 6.3). In an effort to adapt and respond to socio-economic and environmental challenges, several

fishing methods and gear types were observed and used by fishers to maintain high catch returns despite classic signs of fish decline.

Figure 6.3 Multiple user groups on Lake Kariba including small-scale fishers, inland aquaculture, tourism development and small pelagic semi-commercial, single-species offshore

The rapid transition from using passive gillnets to active dragnetting is evident is often interpreted as an adaptation strategy to sustain equivalent catches, while others have diversified livelihoods through crop agriculture, fish processing, small livestock and running small shops of basic goods. Although, small-scale fisheries remain a major economic activity and a source of livelihood for the majority of the local people, there is low compliance with fisheries regulations, and illegal and unregulated human activities resulting into overexploitation. This narrative is slowly changing the environment in a way that is leading to low fish productivity

and a higher risk of the ecosystem collapse (Madzudzo et al., 2014; Nyikahadzoi et al., 2017). In addition to these challenges, are food security concerns owing to the fact that lacustrine communities in the area once had a secure source of livelihood opportunity that is now at risk due to the decline in socio-economic valuable fish species (Mhlanga, 2009). These challenges are exacerbated by the effects of climate change. The predicted changes in rainfall and temperature are likely to affect the distribution of freshwater fish species and alter the biological and food web processes, habitat, and growth rate, with ramifications for fish productivity (Ndebele-Murisa et al., 2011; Hackenberg et al., 2021). The current fisheries policy and regulations do not have provisions or preparedness strategies to address the climate change-related problems in the area (Kefi & Mukuka-Mofya, 2015). These conditions expose the fishery and fishing-dependent communities vulnerable to climate change effects such as droughts, floods, and extreme weather conditions. The finding of this study concurs with previous studies on inland fisheries in the region which describes them to be marginalised in planning processes. This scenario calls for a deliberate policy direction to mainstream climate change interventions which are context and specific to the area (Ngoma, et al., 2010). Such interventions are consistent with the global agendas of the United Nations COP 27 and the 2015 Paris Climate Agreement on efforts to reduce the negative effects of global warming.

This study illustrates the need for an inland fisheries policy to guide and support the development of fisheries in Lake Kariba and the Southern African landscape. It is generally acknowledged that the long-term, sustainable utilisation of the fisheries resources is to promote the social and economic well-being of the fisher communities (Charles, 2011; Nyikahadzoi et al., 2017; Chama & Mwitwa, 2020). This suggests that the development of fisheries requires a sector policy to guide management processes. Results obtained from this study further suggest that, as competition for fisheries resources intensifies in Lake Kariba, small-scale fishers are further deprived of access rights and control, perhaps because of their low social status, poor

living conditions and lack of political influence. Most of the solutions these problems are beyond just fishing expedition. To prevent further deprivation of the fisheries resources, the need for an inland fisheries policy is crucial and will help define user rights, including empowerment and benefits accrued from community participation, which is currently moderate in practice. Although results obtained from the study have not shown a significant decrease in overall fish production over the past 10 years (R^2 Linear = 0.119, $P = 0.248$), the composition and distribution of indigenous fish species of high economic value, like *Oreochromis motimeri* (Kariba bream) are reported to have substantially declined (DOF, 2020).

The cause of this ecological disturbance is attributable to several factors including the introduction of invasive *Oreochromis niloticus*. Despite this being a long-term threat to fisheries productivity, *Oreochromis niloticus* has both negative and positive impacts because, it is comprising of 50% of the total catch in the lake. On the negative front, the introduction of invasive *Oreochromis niloticus* is reported to have led to distortions of pure breed through hybridisation, competition for food and space with indigenous *Oreochromis*. This has threatened the loss of genetically and socio-economically valuable fish species in the lake (Nyirenda, 2017; Irvine et al., 2019). This ecological challenge suggests the need for a regulatory policy to limit possible path ways for invasive fish species in the lake. The principles of responsible fisheries in terms of conservation are well elaborated in the Zambian Fisheries Act No. 22 of 2011. However, the enforcement aspect appears to be weak due to limited human and financial capacity that are constrained by the poor policies.

6.5 Policy implications of the study

This study has shown that fishing remains a key livelihood activity among fishing communities in Lake Kariba. However, some information gaps still remain. These information gaps include a detailed understanding of the fishery resource. It is important to know the actual

status of the fishery if it is endangered or slowly becoming endangered. This will help prescribe a bit more accurate conservation measure. The possibility of the fishery to recover promptly by regulating human activities may be a big question. However, time is a determinant factor. Specific experimental biological studies are required to support this study for a more detailed policy direction. A fisheries policy is basically a guiding instrument intended to outline details of governance and utilisation of fisheries resources. A typical example is the European Union (EU) Common Fisheries Policy (CFP) that was founded to support the long-term sustainable exploitation of fisheries resources and enhance socio-economic benefits in the context of biodiversity conservation, food security and the well-being of the people. Thus, a fisheries sector policy would comprehensively address the current environmental, social, and economic challenges facing small-scale fishers in Lake Kariba. Lack of an adequate national fisheries policy suggests that management of fisheries resources in relation to socio-economic development and food security in Lake Kariba and the region at large has not been holistically addressed (Mosepela & Kolowole, 2017).

At the time this study was undertaken, the fisheries sector in Zambia did not have a standalone fisheries policy, the existing policy was basically a statement covered by the National Agricultural Policy (NAP) (2004–2015) and the second National Agriculture Policy (SNAP-2016-2020), which governs the development of the agriculture sector. However, the two policies did not adequately address the regulations and co-ordination of fisheries (Kefi & Mukuka-Mofya, 2015). The emphasis in the policy is maximizing fish production to meet the national fish deficit. The approach has often denied the local resource users real opportunities and access rights to utilise their resource for optimum food security and biodiversity conservation (Nyikahadzoi et al.,2017). This suggests that institutional arrangements governing fisheries are rudimentary and inappropriate for a common-use resource.

Henceforth, a well-coordinated state-led institutional intervention, informed by a sector policy, will be necessary if maximum social, economic, and positive environmental gains from the development of fisheries are to be achieved. According to Welcome (1998), the foundation for management arrangements in fisheries depends on the value the nation attaches to fisheries; this value is well outlined in the national fisheries policy which shows the framework upon which management strategies are designed. This narrative suggests that fisheries management interventions without policy direction are ill equipped to optimise the emerging challenges and opportunities of fisheries development across the value chain (Weyl et al., 2020). A combination of both political support and implementation capacity are needed in designing a sector policy. One of the major constraints to fisheries management in Zambia and the entire region is the lack of a sector policy to define the functions and responsibilities of stakeholders.

This oversight has created a host of management problems in governance processes, thereby creating barriers between the fishing communities and the fisheries managers (Weyl et al., 2020). It has further compromised the legitimacy and efficiency of the fisheries management and development. Zambia has abundant water resources, including Kavango-Zambezi River system (23 million hectares of water in the form of rivers, lakes and swamps). This accounts for 40% of surface water in Southern Africa (Tweedle et al., 2015). This assertion suggests a window of opportunity for fisheries and aquaculture development. However, this opportunity has not been optimised to bridge the negative imbalance of fish deficit requirements for Zambia which currently stands at 9.9 kg/capita/year. This account clearly illustrates how lack of an adequate fisheries policy stalled the development of the fisheries sector to unleash its potential (Weyl, et al., 2007).

6.6 Theoretical implications of the study

This thesis explores human-environmental interaction in a socio-ecological system threatened by multiple factors. Therefore, institutions of governance are critical in sustainable

conservation practices, because they determine the utilisation and accessibility of any given natural resource, which is the rationale for management (Weyl et al., 2007). This further suggest that conservation practitioners in Lake Kariba and the region at large should account for socio-economic conditions of small-scale fishers including poverty alleviating strategies at the centre of policy formulation (Hara, 2006). This aspect fit so well in interactive governance theory as it provides the rationale for management practices with emphasis on interaction among stakeholders in decision making and policy formulation. Such interactions are sustainable for achieving holistic desired objectives for multiple use resources such as Lake Kariba, as they distinguish both the governing system and the governed system. Furthermore, the study of this nature would bring about harmonized fisheries regulations among member countries sharing the entire Zambezi River basin. This is very crucial for managing transboundary fisheries resources, especially threatened fish species of high economic importance that are migratory in nature (See chapter 4).

6.7 Conclusion

Ignoring the threats to freshwater biodiversity will intensify risks to socio-economic development and eventually undermine future prosperity. A wide range of interdisciplinary interventions that include policy, governance and science are critical to manage the complex human-environmental interaction in a social and ecological system (Ledford, 2015). While this approach has been widely acknowledged, it must be emphasised that interdisciplinary research is multifaceted and time consuming. Navigating pathways to ensure interdisciplinary thinking is a mammoth task, which requires more effective approaches to assist policy makers balance trade-offs and accommodate uncertainty, particularly in a rapidly changing environment. The sustainability challenges and opportunities presented in this document highlight more critical scenarios where studies can inform policy direction enhance resilience. Most important, political will at every point is a very important element that provides for clear objectives to be

incorporated in policy formulation. This may open up space to influence change. In natural resource management, such windows of opportunity include disruptive and mostly serious incidences, such as droughts or floods. At the global scale, the sustainable development goals provide a window of opportunity for a common framework and discussion surrounding sustainable development. This creates a strong linkage between human development and fisheries biodiversity and illustrate the socio-economic importance of inland fisheries at both local and global levels (Lynch et al., 2020).

Considering the competing claims over the use of the fishery and the subsequent rise in the demand for fish, conservation of the fisheries resources is becoming increasingly difficult, and the government has insufficient capacity to deal with this pressure. The transboundary nature of the fishery with other countries like Zimbabwe with a complete diffrent management approach, further complicates effective conservation. Co-management initiatives appear to be a better option. However, for co-management to work effectively, it must be coupled with a policy framework to clearly empower communities and identify localised management practices that are specific and contextual. This can easily be achieved once a policy direction is established, together with other supportive legislation. The objectives of the policy must spell out a clear road map agreed upon by all interested groups. This will create a conducive atmosphere for successful fisheries management to secure food and nutritional security, especially in developing countries where many people suffer from micronutrient deficiency.

6.8 Policy Recommendations

Our study has highlighted the opportunities and emerging challenges associated with management of inland fisheries in Lake Kariba, Zambia including the need for an inland fisheries policy to outline a road map on governance processes. It has further provided a snapshot of the required objectives of such a policy. Based on this study, we describe the

objectives and general purpose of an inland fisheries policy. The policy should advance ecologically sustainable means to provide economic opportunities and food security through managed commercial, subsistence, and recreational fisheries.

- A well-recognised agent must be identified to help design management strategies of inland fisheries; particularly, an existing state-led institution which already has a mandate.
- The policy must be aligned with current existing policies and legislation on conservation of biodiversity, water utilisation, environmental management, economic development, and poverty alleviation.
- The policy must recognise and support commitment related to international protocols and agreements such the FAO Code of Conduct on Responsible Fisheries, the SADC Protocol on Fisheries, and many others.
- The policy must distinguish local resource users as the main economic beneficiaries of fisheries development, while recognising other users as stakeholders or development partners
- It must emphasize and support the harmonisation of institutions governing inland fisheries in the region to support transboundary fisheries co-operation and management
- The policy must provide for fisheries research and identify factors leading to overfishing and environmental degradation.
- In developing the policy, an active community participation arrangement must be considered to define the changes that will reduce socio-economic and environmental challenges.

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Appendices

Appendix A: Household Survey questionnaire

Enumerator: …….

Date…….

Place of interview……. Stratum no……..

1.0 Respondent's personal profile

1.1 Gender: 1) Male 2) Female

1.2 Ethnic group: 1) Tonga…2) Lozi….3) Kaonde… 4) Luvale… 5) Bemba…6) Others (Specify):.....

1.3 Age: 1) 18 – 25 years 2) 26 – 40 years 3) 41 – 55 years 4) <55 years

1.4 Marital status: 1) Married 2) Single 3) Widower 4) Widow

1.5 Education status:

1) Primary education 2) Secondary education 3) Tertiary education 4) None

2.0 location and period of stay in the area

2.1 Name of the chiefdom? .....

2.2 Name of the village? .....

2.3 Is this village your birth place? 1) Yes 2) NO

2.4 Fisher category 1) part-time 2) Full time)3 Seasonal

2.5 If YES, how many years have you lived here?

1) < 1 year 2) 1 – 5 years 3) 6 – 10 years 4) 10 – 20 years 5) >20 years

2.6 If NO, which place do you come from?.....

2.7 For how long have you lived here?

1) <1 year 2) 2 – 5 years 3) 6 – 10 years 3) 10 – 20 years 3) >20 years

2.8 If you have stayed in the village for less than six months, do you just come during the fishing season and you normally go back to your home village after the fishing season?

1) Yes 2) NO

2.9 Why did you choose to leave your home to stay here?

1) Expedition for more income

2) Fishing expedition

3) Others (specify them)

.....

.....

3.0 Environmental conditions

Perceived threats to fisheries production	**Magnitude of severity**				
Pollution	**1)very high**	**2)High**	**3)Medium**	**4)Very low**	**5)Low**
Construction and operation of HEP					
Over fishing					
Poor Legislation					
Land use practices					
Introduction of invasive fish species					

3.1 Perceptions on the fishery condition

Fishery condition	**Fisher perception**			
	Increase	**Stable**	**Decrease**	**Not sure**
Condition of the catchment area				
Diverse user groups				
Water quality				
Water level				
Loss of habitat				

3.2 Does the current condition of the fishery affect your livelihoods

1. Yes 2. No 3. Don't know

3.3 If yes please specify

1. Declined fish catches 2. User conflicts 3. Loss of biodiversity 4. Others

4.0 Climate change related questions

Is this fishing village / camp impacted by climate change?

YES ☐

NO ☐

4.1 In what ways is this fishing village impacted by climate change**?**

……
……

……
……

……
……

4.2 Specify the other climate change related impacts

……
……

……
……

4.3 What human activities would you attribute the observed impacts of climate change?

……
……

……
……

4.4 Specify other human activities you would attribute the observed impacts of climate change.

……
……

……
……....

5.0 Social Conditions

Number of people in the household:

.....

5.1 Type of toilet being used

1) Pit latrine – with ventilation

2) Cultural toilet

3) None

5.2 What is the major source of drinking water?

1) Stand pipe

2) Public/Shared standpipe

3) borehole/well) stream/Lake

5) Other

5.3 Indicate any health concerns in your fishing village?

1) Malaria

2) HIV/AIDS

3) Diarrhœa

4) Malnutrition

5) TB

6) Others, specify them

.....

.....

5.4 Access to essential services

Type of social services	Do you have this service in this fishing village? 1=Yes 2=No	How many of them do you have?	How is the distance to nearest service from the centre of this fishing village 1=less than 1km 2=1 to 5km 3=5.1 to 10km 4=greater than 10 km
Community School			

Primary School			
Secondary School			
Post office			
(Makeshift shop)			
Market			
Clinic			
Electricity Access			
Access to financial services			
Access to mobile networks			

6.0 Fish trade and marketing statistics

	Who is the main buyer of fish in the fishing village? 1=tourists 2=individual local fish traders 3=individual fish trader from the outside district 4=companies 5=outside the country 6=others (specify)	
	How many long-stay traders visit the fishing village/camp per month by gender?	**Indicate number**
	Male fish traders	
	Female fish traders	
	In which form is fish mostly sold? 1= Fresh fish and or chilled 2= Dry and or smoked 3= Salted brine 4=salted cry or smoked	
	What is the most common fish trading method used? 1=Cash 2= Barter	
	List 5 most common goods that are used in barter trade	
	How the fishers/trader transport the fish to the market from this fishing village? (Rank from most to least commonly used)	

	1. Boat	
	2. Bus/lorries	
	3. Hired vehicle	
	4. Bicycle	
	5. By foot	
	6. Ox cat	
	7. Train	
	8. Motorbike	
	9. Other specify	

6.1 Describe the average price by definition of the measures in the table below

	What is the average price of fresh fish per	**Average Price (ZMW)**
	1. Bafa	
	2. Meda	
	3. Small dish	
	4. Heap (estimate weight)	
	5. Kilogram	

6.2. What are some of the goods and services that directly help contribute to your livelihoods?

6.3 Indicate the fishing-related activities that you are involved in?

1) Fishing

2) Fish processing (cleaning, drying, smoking, salting, etc)

3) Net mending

4) Fish buying and selling

6) Boat mending and repairing,

If OTHERS, specify.....

6.4 For how long have you been involved in fisheries-related business in Lake Kariba?

1) Less than six months

2) Between 1 - 5 years

3) Between 6 - 10 years

4) Between 11 - 15 years

5) Between 16 - 20 years

6) Above 20 years

6.5 How do you relate fish catches per unit effort now and the time you started fishing

1) High

2) Very high

3) Just the same

4) Very low

5) Low

6) I'm not sure

6.6 Which period or season in a year do you experience high catches

1) Hot-wet season/ rain season

2) Cold-dry season

3) Hot-dry season/ hot season

6.7 What is your perception about the condition of fish stocks since you started your fishing activities?

Condition	**Increased**	**Decreased**	**Same**	**Not sure**
Abundance of fish catches				

7.0 Livelihood status in relation to fishing activities

7.1 What is your mode of fish disposal?

1) Selling only

2) Consumption only

3) Both selling and consumption

4) Batter system

7.2 If selling is the major aspect, how have been the sales of fish?

1) Very good 2) Good 3) Average 4) Low 5) Very Low

4.1 If Low or very low, what are the reason (s)?

1) Low catches

2) Low fish demand within community

3) High transaction costs to market places

5) If OTHERS, specify) .....

7.3 How are the sales now compared to the time you started selling fish?

1) Increased 2) Slightly increased 3) Same 4) Slightly reduced 5) Decreased

7.4 What are your alternative sources of livelihood other than fishing?

1) Fish farming

2) Crop agriculture

3) Livestock farming

4) Buying and selling of other goods

5) Employment

6) Others If

OTHERS, specify: .....

7.5 What are your other sources of income 1) Fish farming

2) Crop/vegetable farming

3) Livestock farming

4) Beekeeping

5) Buying and selling of other goods

6) Employment

7) Others If OTHERS, specify:.....

7.6 Do you think fish farming as a business can be the best alternative to catching fish? 1)Yes 2) No 3) Not sure

7.7 If YES, why do you feel it could be a better alternative?

1) It can help reduce overfishing on Lake

2) It can supplement the declining fish catches on the Lake

3) It is seen as an employment opportunity

4) It can be seen as alternative livelihood strategy

4) Others (Specify): .....

8.0 Agricultural Information

Are there any agriculture activities practiced in this fishing village? **1=Yes** ☐ **2=No** ☐ If the answer to the above question is yes, kindly indicate below			
Are the following gardening activities done in this fishing village/camp?	**GARDEN CROPS**	**Yes**	**No**
	Green leafy vegetables		
	Tomatoes		
	Onions		
	Carrots		
	Okra		
	Others (specify)		
Are the following crops cultivated in this fishing village/camp?	**FIELD CROPS**	**Yes**	**No**
	Maize		
	Cassava		
	Soya beans		
	Beans		
	Sorghum		
	Millet		
	Others (specify)		
Which of the following livestock are raised in this fishing village/camp?	**LIVESTOCK**	**Yes**	**No**
	Cattle		
	Goats		
	Pigs		

	Donkeys		
	Sheep		
	Poultry		
	Others (specify)		

9.0 Current governance system and community participation in fisheries management

9.1 Do you feel that fish should be sustainably harvested from the Lake by fishers?

1)Yes 2) No 3) Not sure

9.2 If YES, why should it be sustainably harvested?

1) Access by future generation also

2) More income

3) More food

4) More fish in Lake

5) Others (Specify):.....

9.3 Who is responsible for fisheries management?

1) Fisheries Department 2) Civil society organization 3) Fishing village management committee

6) Others If OTHERS, specify: .....

9.4 Are you satisfied with the current management regimes

1) Very satisfied 2) Satisfied 3) Average 4) Unsatisfied 5) Not unsatisfied

9.5 If you are SATISFIED, Kindly give reasons for your response.

.....
.....
.....

9.6 If UNSATISFIED, kindly give reasons.....
.....
.....

9.7 Do you think as an individual, you are supposed to be engaged in fisheries management?

1) Yes 2) No 3) Not sure

9.8 If yes, give reasons

……

9.8 Are you aware of any organization involved in fisheries management?

1) Yes 2) No 3) Not sure

9.9 If the answer is yes, are you content with their current fisheries management arrangements

9.10 Are you contained with the manner in which the fishery resources are managed?

9.11 If the answer is yes, to what extent?

1) Not satisfied 2) Satisfied 3) Average 4) Uunsatisfied

9.12 Are you engaged in any decision-making process for fisheries conservation?

1) Yes 2) No 3) Not sure

END OF THE QUESTIONNAIRE SURVEY, THANK YOU FOR YOUR TIME

Appendix B: Focus group discussion guide for fishers

1.0 CONDITION OF THE FISHERIES RESOURCES ON LAKE-KARIBA

1.1 How do you rate the fish catches from the Lake between now and 10 years ago?

1.2 What has been your profile in light of the current status of fish catches?

1.3 If the fish stocks have reduced or increased over time, what could be the possible reasons behind the current condition?

1.4 How do you relate with other fishers from outside Lake Kariba?

2.0 LIVELIHOODS AND ADAPTATION STRATEGIES

2.1 If the fish stock has been declining over time, how has this affected your livelihoods?

2.2 Are you engaged in any other form of income generation?

2.3 Are there possible alternative sources of income generation proposed by central government in the fishing community? Are there conditions required to be in place before one takes up alternative sources of income? Kindly outline any if?

2.4 Are there any social services offered in this area for instance medical facilities, markets, schools, churches, safe drinking water facilities, etc, in the fishery area that can improve or better livelihood?

3.0 FISHERIES RESOURCE GOVERNANCE AND COMMUNITY PARTICIPATION

Are you know your mandate in sustainable fisheries management? If any, what is the extent of engagement in the sustainable utilization of fisheries resources

3.1 Are there community structures that are responsible for ensuring that fish is sustainably harvested? If any, who are the major participants and what has been their major roles in supporting sustainable fisheries management

3.2 Are you content with the level of organisation regarding sustainable fisheries management

3.3 How has been the participation of traditional leaders in the decision-making process regarding fisheries management

3.4 What are your personal observations with regard to community participation in fisheries resources management

3.5 Would you promote full community participation compared to government control in promoting sustainable fisheries management

3.6 What could be the opportunities and challenges of community participation in fisheries resource management?

3.7 Are you conversant with any statutes or regulations that promotes full community participation in fisheries resources management?

THANK YOU VERY MUCH FOR YOUR PARTICIPATION

Appendix C: Interview schedule for key stakeholders' participants

Traditional leaders, department of fisheries Ministry of Agricilture World vision

Parks and wildlife, Local government and fisher associations

1.0 **Introduction**

1.1 What is the role of your organization**?**

1.2 For how long have you worked with your institution or organization

2.0 **Status and condition of the fishery**

2.1 What are your observations with regard to fisheries and livelihoods

2.2 Since when did you observe or notice the changes of fisheries condition?

2.3 What are your perceptions with regards to the current status of the fishery and its catchment (last ten years)

2.4 How do you rate fish catches between now and 10 to 15 years ago?

2.5 If you think fish stocks have been declining over time, what could be the major reasons?

2.6 How is the population dynamics in this fishery over the past 10 to 15 years ago?

2.7 Do you think population changes has an impact to the fishery resources

3.0 **Livelihood strategies**

3.1 Are there alternative income source or activities that are currently practiced by the fisher communities

3.2 Are there possible for financial lending institutions that can help the fishers facilitate loans for other sources of income generation?

3.3 How do you rate the standard of living during the last 10 to 15 years ago? Are the fishers engaged in other forms of income generation activities? If any, what could be the other alternatives?

4.0. **Institutions and governance layers**

4.1 How has been the governance structure for the management and conservation of the fisheries resources in this fishery?

4.2 What are the successes and challenges in the existing governance system, that is, a

4.2 How do you think it should change in response to the current fishery condition?

4.3 How do you rate stakeholder participation in fisheries resources management?

4.4 What kind of fisheries management challenges have you observed in your engagement with fisher communities over time?

Appendix D Key informant guide questions for the systematic review paper

Questions to the elite officials at KAZA secretariat in Botswana

1. Briefly explain to the activities of KAZA with regards to transboundary fisheries management
2. What are some of the challenges and success of transboundary fisheries co-management in KAZA-TFCA?
3. How is the differences in terms of institutions and legal frameworks affect transboundary fisheries management?
4. What are the major differences and similarities in terms of policy and other institution in partner countries that may have a bearing on the operations of Transboundary fisheries management in KAZA-TFCA?
5. What is the role of KAZA in ensuring that there is progress in issues of transboundary fisheries management?

Questions to officers and leaders of conservancies

1. How is the response of fisherfolks with regards to transboundary fisheries management at local level?
2. What are some of the challenges you are facing in the implementation of transboundary fisheries management?
3. Is it helpful to have co-management at local level let alone transboundary fisheries management?
4. How is the response of traditional leaders with regards to fisheries management?

Questions for experts, academia and conservation practitioners

1. Briefly describe the status of the fishery with regard to governance in KAZA-TFCA
2. What are some of the past and present experience that can help the sustainability of inland fisheries in the region
3. In your own analysis do you think transboundary fisheries management has worked well KAZA-TFCA since its inception?
4. What are some of the challenges and opportunities?
5. What needs to be done if transboundary fisheries management is to be sustainable?

Thank you very much for your attention