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**SMALL-SCALE FISHING OPERATIONS AT DARWENDALE DAM: CHARACTERISTICS,
CONTRIBUTIONS AND CHALLENGES**

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ABSTRACT

Fish resources have long played a critical role in sustaining livelihoods, contributing to food security, economic development, and ecological balance in many societies. In Zimbabwe, limited empirical documentation exists on the operational dynamics of small-scale fisheries in inland reservoirs, including Darwendale Dam. This study aimed to examine small-scale fishing operations at Darwendale Dam, with particular focus on fishers' characteristics, fishing practices, catch composition, and the challenges affecting sustainability. The specific objectives were to: (i) characterize the fishing methods employed; (ii) identify the types and quantities of fish caught per month; (iii) assess environmental factors influencing fish populations; and (iv) evaluate the policy and institutional frameworks governing small-scale fisheries in the area. A mixed-methods descriptive research design was adopted, integrating quantitative and qualitative approaches. Data were collected through structured questionnaires, semi-structured interviews, and direct observations. Quantitative data were coded and analysed using IBM SPSS Statistics, where descriptive statistics (frequencies, percentages, and means) were generated to summarize fishing practices and catch composition. Inferential analysis, specifically one-way ANOVA, was conducted to compare mean daily catch weights across fish species. Qualitative data were analysed thematically to complement and contextualize the quantitative findings. The results indicate that gillnets are the predominant fishing method, accounting for 65% of usage, while lines, hooks, and spears constitute 35%. Three categories of fishers were identified: registered cooperatives, registered individuals, and unregistered fishers, with all registered operators holding permits issued by ZimParks. The dominant species caught was *Oreochromis niloticus* (bream), contributing over 50% of monthly catches, followed by *Clarias gariepinus* (African sharp tooth catfish) and *Cyprinus carpio* (common carp). Statistical analysis using SPSS revealed no significant differences in mean daily catch weight among species ($p > 0.05$). Despite this, the study found a significant decline in overall fish catches, accompanied by a shift toward more resilient and invasive species, suggesting overexploitation and ecological stress. This concludes that while small-scale fisheries at Darwendale Dam remain vital for livelihoods, their sustainability is under serious threat. Strengthening regulatory enforcement, promoting community-based management, and supporting fishers' capacity for sustainable practices are critical for improving fisheries governance and resource conservation.

APPROVAL FORM

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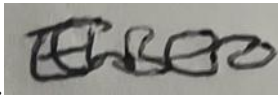
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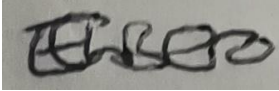
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DEDICATION

I dedicate this project to my family for the encouragement and support during the research and writing dissertation

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While a completed dissertation bears the single name of the student, the process that leads to its completion is always accomplished in combination with the dedicated work of other people. Without the support, patience and guidance of the following people, this study would not have been completed. It is to them that I owe my deepest gratitude.

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CONTENTS

ABSTRACT.....	i
APPROVAL FORM.....	ii
RELEASE FORM.....	iii
DECLARATION FORM.....	iv
CHAPTER 1:	1
1.1 Background of the study	1
1.2 Statement of the problem.....	3
CHAPTER 2: LITERATURE REVIEW	7
2.1 Overview of fisheries worldwide	7
2.2 Importance of fishing.....	7
CHAPTER 3: MATERIALS AND METHODS	17
3.1 Study area.....	17
3.2 Research Design	18
3.2.1 Target Population	19
3.2.2 Sampling.....	19
3.3 Research Procedure	19
3.3.1 Water quality assessment	20
3.4 Data Collection.....	21
3.5 Data Analysis	21
CHAPTER FOUR: RESULTS	23
4.1 Demographics of the respondents.....	23
4.2 Fishing methods used at Darwendale Dam	24
4.3 Types of fish types and quantities caught by small scale fishers in Darwendale dam.....	26
4.4 Environmental factors influencing fish population in Darwendale dam.....	28
4.4.2: Effect of Seasonal Changes in Water Levels	32
4.4.3: Invasive Species.	32
4.4.4: Water hyacinth and Its Effects on Fishing Efficiency.....	33
CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS	37
5.1 Discussion	37
5.2 Conclusion.....	40
5.3 Recommendations.	41
REFERENCES	42

APPENDICES	47
Appendix 1: The questionnaire used in the research.....	47
Appendix 2 Interview Guide for Responsible Authority, Management, and Institutions.....	55

CHAPTER 1:

1.1 Background of the study

Fish are a backbone for many societies around the world as they are valued for their nutritional and economic value. Fisheries provide livelihood to millions of people worldwide, and more than 1 billion people rely on fish as a source of animal protein, especially where other sources of animal protein are scarce or expensive (Bene, 2006). Fishing is very important in developing countries, and small-scale fisheries contribute to the largest proportion of fish stocks (Mathew, 2001). It is estimated that over 30 million fishers are engaged in small-scale fisheries throughout the world (Coates, 2002), with 95 percent of them found in developing countries, contributing approximately 58 percent of the total global annual fish catch (Bene, 2006).

Income generation and employment opportunities are some of the notable economic benefits of Fishing contributing to the national Gross Domestic Product (GDP), a source of livelihoods, and food security. Fishing provides a source of income for fishers and their families (IUCN, 2017; FAO, 2020). People are employed in the fishing industry in processing and trading. Typically, countries such as China, India, and Indonesia are among the leading fish-producing countries in the world. Fisheries are a source of livelihoods to approximately 227,000 full-time fishers in Central and West Africa, with an approximate gain of \$295 million annually from 570,000 tonnes of catch (FAO, 2010). Fishing aids food security. It ensures a steady supply of food. Fish is a primary source of high-protein food (IFAD, 2012) for many communities and is very rich in nutrients like omega-3 fatty acids. Small-scale fishing has led to the diversification of the industry, which saw the emergence of other activities such as worm harvesting, net-making, boat-building, engine repair, and maintenance, resulting in the growth of marine and inland fishing communities (FAO, 2020).

Fish is essential in East Asia and Africa, for instance, where it supplies more than 50 percent of the animal protein intake in the diet of the 400 million people living in some of the poorest countries of the World (FAO, 2020). Small-scale fisheries have contributed to poverty reduction through income generation and providing safety nets, thereby reducing vulnerability in Southern Africa in countries such as Mozambique and Tanzania (Ninnes, 2004). In Ghana, official data showed that inland catches averaged 75,000 tonnes per year. Surveys carried out at Lake Volta

indicated that estimates of fish catches are around 346,000 tonnes (FAO, 2008). Furthermore, small scale fisheries play a major role in employment creation as the industry indirectly creates employment for fishery related activities such as nets and boat making and fish marketing (Bene, 2006) Small scale fisheries contribute to poverty alleviation and economic development through income generation, employment and food supply. (World Bank, 2001).

Zimbabwe is a landlocked country with no natural lakes, and its inland fisheries are largely based on man-made reservoirs constructed for water supply, irrigation, and hydroelectric purposes. Despite this, the country's rivers and dams support a significant freshwater fishing industry. The sector is dominated by both commercial and small-scale fisheries targeting key species such as *O. niloticus* and *O. mossambicus* (tilapias), *C. gariepinus* (African sharptooth catfish), and *C. carpio* (common carp).

Fisheries in Zimbabwe are primarily managed by the Zimbabwe Parks and Wildlife Management Authority, which regulates access, licensing, and conservation of aquatic resources. The freshwater fishing industry represents an important socio-economic sector, supporting livelihoods, enhancing food security, and contributing to local economies, particularly in rural communities (FAO, 2017).

Fishing is a significant contributor to Zimbabwe's economy, accounting for about 2% of the country's GDP (International Fund for Agricultural Development (IFAD), 2018). Though fisheries have a minimal contribution to the country's Gross Domestic Product, they have contributed to food security in addition to employing local people in the country (Zimbabwe Ministry of Fisheries and Aquaculture, 2020). The fishing industry in Zimbabwe employs over 100,000 people both directly and indirectly and generates approximately USD 100 million in revenue annually (Zimbabwe Ministry of Fisheries and Aquaculture, 2020).

Small-scale fisheries play an important role in providing livelihoods to many people in Zimbabwe, contributing to the meeting of the National Development Strategy on Poverty Reduction. Despite this significant role, less prominence has been given to small-scale fisheries, resulting in their vulnerability. This study will explore the operations of small-scale fisheries at Darwendale Dam in Zimbabwe.

1.2 Statement of the problem

Small-scale fisheries play a crucial role in providing livelihoods, food security, and socio-economic development in many rural communities across Zimbabwe. Darwendale Dam, one of the significant inland water bodies in the country, supports a growing population of small-scale fishers who depend on fishing as a primary or supplementary source of income. Despite the importance of this sector, there is little information documented (specifically for Darwendale dam) on how the fishers operate, the types of fish, fishing methods, and the amount of their catch per annum, and the challenges they face as fishers, despite fishing permits being issued every year (FAO,2007). The available little information's authenticity is unverifiable as it is based on fisheries reports for quota setting, yet the information is important for monitoring, management, and regulation of the fisheries in the Darwendale dam (Nhiwatiwa, 2020). In addition, multi organization management of the lake between Zimbabwe Parks and Wildlife Management Authority (ZPWMA,2012), what it has in place to properly manage the dam to ensure that there is efficient management of fish resources. This study seeks to fill this knowledge gap by examining the socio-economic contributions, challenges, and sustainable management of small-scale fishing operations at Darwendale Dam.

1.3 Aim

To examine the small-scale fishing operations at Darwendale dam, focusing on the characteristics, contribution, and challenges faced by fishers

1.4 Objectives.

1.4.1 To characterise the attributes of the small scale fishers and establish the methods of fishing used in the Darwendale dam by small-scale fishers.

1.4.2 To identify species composition and quantities of fish caught per month by small scale fishers in Darwendale dam.

1.4.3 To establish environmental factors influencing fish populations around the Darwendale dam.

1.4.4 To investigate the existing management framework and policies governing small-scale fishing operations at Darwendale dam.

1.4.5 To explore the challenges faced by small-scale fishers at Darwendale dam.

1.5 Research questions

1.5.1 What fishing methods and equipment are used by small-scale fishermen to harvest in the Darwendale dam?

1.5.2 What is the quantity of fish catches per month and what is the species composition in the Darwendale dam?

1.5.3 What environmental factors influence fish populations in the Darwendale dam?

1.5.4 Which management framework and policies govern small-scale operation at Darwendale dam?

1.5.5 What challenges and opportunities are faced by small-scale fishers at Darwendale dam?

1.6 Key Terms (Operational Definitions)

Small-scale fishers

Individuals or households engaged in fishing activities at Darwendale Dam using relatively low-capital, labor-intensive methods, primarily for subsistence and/or local market sales.

Fishing operations

All activities involved in fish harvesting, including gear selection, fishing techniques, effort, and post-harvest handling practices.

Fishing methods

The techniques and gear used to catch fish, such as gillnets, hook and line, traps, and spears.

Fish catch (yield)

The quantity (kg) and types (species) of fish harvested by fishers within a specified time period, typically measured monthly.

Fish species composition

The variety and relative abundance of different fish species caught at Darwendale Dam.

Environmental factors

Physical and chemical characteristics of the water body, including temperature, pH, dissolved oxygen, turbidity, and nutrient levels, which influence aquatic life.

Fisheries management framework

The set of policies, regulations, institutions, and governance systems (e.g., licensing, quotas, enforcement mechanisms) that control fishing activities at Darwendale Dam.

Challenges (constraints)

Difficulties encountered by fishers, such as limited access to equipment, market barriers, environmental changes, overfishing, and regulatory restrictions.

1.7 Significance of Study.

Data on historical fish catch trends will be of paramount importance as it will show whether there is an increase or decrease in fish production, and this will go on to depict its effects on the fishers' livelihoods, identifying vulnerabilities and needs to inform policymakers to come up with intervention strategies. The types of species harvested help identify the targeted species. This will help improve the breeding of the species and put in place measures to control overfishing and extinction. This will help the fisheries management to come up with regulations and conservation efforts to ensure sustainable fishing of the targeted species. Most fisheries have not been well managed with an open access system still practiced in over 10 000 small dams existing in Zimbabwe including Darwendale dam (FAO, 2014) The major reason following the collapse of the fishing industry has been lack of nationally coordinated consistent fish stock assessment program, no reliable fisheries statistics to be used for planning towards the socio-economic needs of fish dependent communities. (Donda, 2006) Fishing methods will reveal how they are used by fishers, and these types will help to measure the sustainability of fishing. This will help to bring in innovative and sustainable fishing practices. The methods will help identify potential environmental impacts. Fishing method is an important quality attribute for different fish stocks, as it determines the price determination process, fishing management, and governance. (FAO, 2020) Fishing as a livelihood and source of income quantifies' economic importance, identifies livelihood vulnerabilities, and informs poverty reduction strategies (IFAD, 2018). Challenges faced by fishers will help to identify key constraints and vulnerabilities. This will help to inform targeted support and policy interventions, thereby enhancing understanding of fishers' experiences.

Overall, this will help evidence-based policy and decision makers, as well as enhance understanding of small-scale fisheries dynamics and operations. This supports climate-resilient and environmentally sustainable fishing practices. This will help policymakers come up with capacity-building and empowerment initiatives. Having achieved these objectives, this research will provide valuable insights to fisheries management and conservation, and livelihood enhancement. Environmental sustainability, policy, and decision making. Fisheries management has focused on raising incomes by increasing the efficiency of fishing effort. The threat to resource depletion due to overfishing has been tackled by the top-down fisheries management policies (FAO, 2012). Measures used to control resource overexploitation include operator licenses, restrictions on vessel capacity, closed seasons, or closed fishing zones. Additionally, parametric controls can be implemented, which include spawning and nursery area limited access, closed seasons, and size limits (Donda, 2011). This will be incorporated to reduce overexploitation and ensure sustainable fishing. As stated earlier, very little work has been done with regard to studying activities of small-scale fishing in Zimbabwe, particularly at the Darwendale dam and institutional involvement in the sector. From a policy perspective, the findings of this study would contribute to shaping policy on small-scale fishing in Zimbabwe. For Zimbabwe in particular, the findings are a bonus in that they are evidence-based policy suggestions and as a reflection of or a reality of small-scale fisheries at Darwendale dam (ZPWMA, 2012). Furthermore, findings help in future collaborative or related research calls. Environmental, socio-economic, and political pros and cons brought by small-scale fisheries can be identified through research findings, especially in marginalized areas.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of fisheries worldwide

Fishing is one of the oldest professions that has sustained livelihood since time immemorial. Globally, it is a recognized source of protein. Studies were carried out in South east Asia to assess the relative contribution of small-scale and industrial fisheries to national food security conducted a comparative analysis of the degree to which the industrial and small-scale sectors support food security found out that total marine fish catch from four Southeast Asian countries, Cambodia, Malaysia, Thailand and Vietnam, totalled 282 million from 1950 to 2013, with small-scale sector catches being underestimated by an average of around two times. (Pauly 1997) When the amount of fish that is diverted to fishmeal is omitted, small-scale fishers contribute more food fish for humans than do industrial fisheries for much of the period until the year 2000 (FAO, 2007).

Fish resources in Indonesian waters are proven biological resources that can provide a major contribution to the survival and welfare of the nation (FAO, 2012). However, there is a lot of literature and previous research saying that until now, the fishing community, both in groups and as a whole, is still classified as poor people when compared with other community groups in the agricultural sector (IFAD, 2018).

At Lake Kariba, small-scale fishing started in 1962 with 208 licensed fishers. That is according to a survey which was carried out by the Zimbabwe Parks and Wildlife Management Authority in 2011. Sanyati basin had 208 fishers in 1962, and the number increased to 1404 fishers in 1998 (Songone, 2000). Small-scale fishers are found on the river Zambezi. Fishing is more concentrated in fishing camps. There are 41 camps and 35 fishing villages. Fishing camps are regulated by ZPWMA.

2.2 Importance of fishing

The fishing industry is the cornerstone of the global economy, supporting 61.8 million jobs and contributing \$406 billion annually, which is from capture fisheries and aquaculture (FAO, 2022). It supplies over 3 billion people with essential protein especially in developing nations where fish accounts for over 50% of animal protein (Virdin and Basurto, 2019) Small-scale inshore fisheries stand as the backbone of socio-economic well-being of coastal and inland communities throughout the world (Béné, 2006; Harvey, 2006; Teh and Sumaila, 2013), particularly in the tropics where the majority of countries with heavily fish dependent populations are found (Golden et al., 2016).

In these locations, fish is crucial for food security and health, providing not only daily protein requirements but also a range of essential micronutrients that fend off diseases resulting from malnutrition. The importance of fish to society is more so given that it is relied upon by some of society's most vulnerable groups, including the poor and stateless migrants, who might otherwise have no other means of livelihood (Béné et al., 2007, 2010). These fisheries generated national income, supplied food to feed the country, and provided local jobs that were ironically supposed to benefit poor fishing households, i.e., small-scale fishers. Fisheries in the tropics are predicted to fall by as much as 30% by 2050 as a result of global ocean warming and changes in net primary production (Cheung et al., 2016). Despite this abject negative outlook, national governments are not well-prepared to deal with their potential socio-ecological outfalls, not least due to glaring gaps in knowledge about the magnitude and nature of small-scale fisheries (Pauly, 1997, 2006; van Zwieten et al., 2002). There is thus a very real and urgent need to assess the role of small-scale fisheries, and to translate this knowledge to timely and relevant policies on sustainable fisheries and marine management for food security (Teh et al., 2007; Barnes-Mauthe et al., 2013).

In Africa, Fisheries are important for livelihoods, food security, and cultural resilience, yet it is still marginalized. A study in Ghana has shown that inshore artisanal fishery is a major source of fish production, accounting for 80% of the total annual fish supply (MoFAD, 2017). The main aim of artisanal fishers is to continue to supply fish to meet their household needs and for domestic markets. The artisanal fishery operates actively in over 300 landing sites in several coastal communities along the 550 km coastline of Ghana and supports approximately 124,000 fishers (Amador et al., 2006; CRC, 2013). Several coastal communities in Ghana engage in subsistence farming, small trade, artisan works, factory work, mining, and sand mining as their livelihood strategies, and these are mostly undertaken concurrently with fishing-related activities (Mensah & Antwi, 2002). However, Asiedu et al. (2013) report that artisanal fishing contributes 80% and 85% to the total 77 household income of fishers in the Ahwiam and Elmina communities, respectively. In Malawi, research was done on fisheries management, which included patches of traditional, modern, and postmodern. Malawi as a nation battles with several national pandemic as this has crippled their economic performance thus they have resorted to fisheries as the major livelihood option, the aquatic biodiversity of Lakes Malawi, Malombe, Chiuta, Chilwa, and the Shire River is all the more important, as it provides primary or secondary livelihoods for an estimated 350,000 people, (FAO, 2005) and contributes to the incomes of an estimated 1,000,000 people (Bene,

1999). Finally, fish is the cheapest source of animal protein available to Malawians, and due to population growth, the annual per capita amount of fish available has decreased from 12.9 kg in 1976 to just 3.6 kg in 2001 (FAO, 2005).

In West Africa, research was conducted by Bene et al, (2004) to address the following question: "What are the challenges of managing fisheries with reference to poverty alleviation within the specific context of West African small-scale fisheries?" (Poverty is a common, although not systematic, characteristic of fishing communities. Poverty in fisheries may occur as a result of production failure (e.g., Malthusian crisis). However, it was noted that poverty in fisheries can also occur, even if fish are caught and surplus (rent) is generated as a consequence of institutional malfunctioning (e.g., distribution or entitlement failure). These two generic scenarios of poverty occurrence emphasize the relation between them. A first case of fishery-related poverty may occur in the form of 'production-failure' poverty. This situation corresponds to the case where members of fishing households are unable to derive enough economic surplus from the fishing activity to cover their 'minimum needs'. This production failure is due either to a technical and/or economic failure (lack of efficient/cost-effective fishing gears) or to an ecological crisis (Bene et al, 2004).

Locally, the importance of fishing in Zimbabwe is critical for rural food security and employment. Several fishing centres, namely Kariba, Mutirikwi, Tugwi Mukosi, and Chivero, support 40,000 plus livelihoods with annual yields of 40 metric tonnes from Mutirikwi typically (Mapedza, 2011). Fishing also has cultural significance. Communities like the Batonga people are known to have been a fishing community before the construction of the Kariba dam. Up to the present day, fishing has continued among the Batonga as a cultural lifeline. (Viridin and Basurto, 2019). Besides being very vital, fishing in Zimbabwe is undermined by weak law enforcement and climate variability, among other factors.

The fishing industry's importance covers global food systems, regional economic resilience, and local cultural survival. While international frameworks like the FAO Code of Conduct and SDG 14 aim for sustainability (FAO, 2022), there are regional and local gaps in empowering small-scale fishers. In Zimbabwe, there is a need for co-management models to balance equity and ecological health (Zvinorova, 2016). Fisheries management in Zimbabwe dwells much on balancing aquaculture growth and artisanal fishing with ecosystem health, typically in Lake Kariba and other major reservoirs. Literature highlights a shift toward co-management, addressing overfishing in

small water bodies, the impact of climate change on small-scale fishers, and a push for improved, sustainable tilapia hatcheries (ZimParks, 2017). While historically centralized, management is transitioning towards co-management. Studies on Lake Chivero and other sites indicate that community-driven, participatory approaches are being implemented to mitigate poaching and manage resources (Mutasa, 2018). To address the high level of dependence on fishing and lack of other income-generating activities, Zimbabwe Parks and Wildlife Management Authority (ZPWMA) and Rural District Councils (RDCs) had to consider promoting the aquaculture of tilapia. There is already an EC-funded small-scale tilapia aquaculture program in the fishing villages, which is coordinated by World Vision Zimbabwe (FAO, 2017). The relevant authorities considered upscaling the program through capacity building and fish stock supply. They also facilitated the involvement of small-scale fishers in the Zimbabwe Command Livestock Program with the aim of improving the livestock assets of small-scale fishers. This program was launched in May 2017 as part of the Zimbabwe Agenda for Sustainable Socio-economic Transformation (ZIMASSET), and was spearheaded by the Ministry of Agriculture, Mechanization and Irrigation Development. This program targets beef, dairy, and poultry, and it was introduced to the fishing camps who have the option of keeping livestock (Mutasa, 2018). All these are efforts implemented at different reservoirs to improve management of fisheries, given its importance for the livelihoods of Fishers.

2.3 Characteristics of Fisheries and Fishers

Small-scale fishing accounts for 90% of the World's fisheries, and nearly half of global fish catches are for human consumption. Small-scale fishing is distinguished by its labour-intensive, low-technology methods and reliance on indigenous knowledge systems. Most small-scale fishers are artisanal using cheap, accessible methods, which include canoes, sailboats, gillnets, traps, and hand lines (FAO, 2019). They are non-formal in their trade, and processing is mostly locally based and is done at the household level by individuals. It involves the utilization of low capital and energy, with the main objective of family consumption. The definition and terminology for small-scale fishers vary from country to country (Pomeroy et al., 2009; FAO, 2011b). Small-scale fisheries are most consistent with traditional fisheries, which include those fishers who use traditional gears such as hook and line, bag nets, traps, lift nets, seine nets, barrier nets, and scoop nets. In Vietnam, fisheries are commonly classified as nearshore and offshore rather than as small and large scale (Pomeroy et al., 2009), while in Cambodia, the term coastal fisheries is used, and involves family-

scale fishing units operating from the coast to a depth of 20m (FAO, 2011b). Thailand's Department of Fisheries' definition is based on boat gross tonnage, whereby small-scale is defined as inboard powered boats of less than 10 GT, and that generally operate inshore. According to FAO, small-scale fishers are traditional fishers who involve fishing households using relatively small amounts of capital and energy, relatively small fishing vessels, making short trips, close to the shore, mainly for home consumption. Small-scale fisheries are defined as those that exhibit some or all of the following characteristics: primarily geared toward household consumption, sale at the local level, or export in the case of high value species; usually at low level (primary and secondary) of economic activity; for fulfilling cultural or ceremonial purposes; non-mechanized, or involve low technology and low capital investment; undertaken by the fisher and/or family members only; conducted within inshore areas; and minimally managed (Teh & Sumaila, 2013).

From a livelihoods perspective, small-scale fisheries are often poverty-driven and achievable in communities with water resources. The role of small scale fisheries in providing and inhibiting fishing or non-fishing livelihoods is a key determinant of the capacity of the sector to alleviate or exacerbate poverty (IFAD, 2018). Small-scale fishing can be a catalyst and anchor for other productive activities to stimulate the development of complementary and alternative productive ventures necessary for sustainable poverty alleviation (Scoones, 2015). Small-scale fishers, like any other entrepreneurs, require a complete package of business development services to thrive and grow. In addition to technology, they require skills in business planning and management, fishing methods, sustainable environmental management, access to credit, and profitable markets (Guyader, 2007a). With the support, especially financial, there will be an increase in production in the sector (Utete, 2022). However, local governance structures and institutions are typically underdeveloped or non-existent in areas or regions with substantial small-scale fishing. Institutional negligence in the supervision of small-scale fisheries results in environmental degradation and the lagging behind of the sector in terms of development. Small-scale fisheries face numerous challenges, which include geological, technological, legal, human resource, marketing, organizational, and financial challenges. Cooperatives are often the only means for small-scale fishers to improve their viability and to manage and reduce environmental, social, and cultural risks, or to improve their access to technologies or marketing structures that could enhance their economic opportunities (Hutching, 2000).

On the other hand, in many developing countries, particularly in Sub-Saharan Africa, women are involved in the processing and trading sectors of both capture fisheries and aquaculture. Women's involvement in processing and trading as a real economic empowerment tool (Overa, 1998). Heck and Béné (2007) also highlighted the fact that in Africa, women's involvement in processing and marketing contributed to securing their children's nutritional needs, and women would not be able to do it if they had to rely on men's income. In the Kafue floodplain, Zambia, the women used to play an important role in fishing as a customary practice to compensate for food scarcity during the lean season; however, currently it has become difficult since fishing is commercialized and little space is given for local women to continue the practice (Merten & Haller, 2008). A similar trend was observed in a study in the Salonga area in the Congo, where women usually catch small fish by the traditional basket trap methods. These fish are mostly for household consumption, while the fish caught by men are sold to the market in a larger proportion (Béné et al., 2009).

Another study in the Kafue flats, Zambia (Merten & Haller, 2008) found links between reduced access rights to fishing for the local population, and household food insecurity and child growth. Fishing activities were an important customary practice for the local women to cope with food insecurity, especially during a scarcity period. Commercialization of fish and increased migration made it difficult for the locals to engage in fishing, resulting in increasing vulnerability to food insecurity. This was supported by the findings of a higher prevalence of malnutrition in fishing communities (39.8%) than in agricultural (22%) or agro-pastoral (25.3%) communities during the southern African food crisis in 2002 to 2003 (Kawarazuka, 2010).

Zimbabwe's small-scale fishing is done at the household level by individuals living near man-made lakes like Kariba, Chivero, Mutirikwi, and Darwendale. It involves the utilization of low capital and energy, with the main objective of family consumption. Zimbabwe alone has over 2 million people engaged in small-scale fishing. (FAO, 2007) They make use of simple methods and tools such as gillnets, traps, and longlines. Both men and women participate in fisheries, while men focus on capture and women on trading and processing. However, they are often face challenges such as market price fluctuation, lack of cold storage, and restrictive licensing that favour elites over poor fishers (Béné et al., 2009). Climate variability, invasive species, and pollution are other challenges that are affecting small-scale fishing operations (Mutasa, 2018). This research seeks to dig into and unveil the small-scale fishing operations at the Darwendale dam.

2.4 Approaches and management of fishing and fisheries

Globally, the management of fisheries is shifting towards Ecosystem-Based Fisheries Management (EBFM), which prioritise holistic stewardship, balancing species interaction, habitat health, and human needs. The European Union uses the Common Fisheries policy to manage water resources so as to combat fish stocks that are declining. Programs have been put in place to monitor, conserve fish stocks, regulate fishing, share out the resource policing, restructure fleets, and maintain employment within fishing communities (FAO, 2017).

Approaches to managing small-scale fisheries have been less effective in developing countries. Small-scale fisheries are difficult to manage due to their diversity and complexity (Berkes, 2003). Fishery managers face an overwhelming range of approaches, frameworks, perspectives, and methods for analysing fisheries management. There are three primary approaches used in fishery management, namely ecosystem-based management, rights-based management, and management for resilience (Andrew and Evans, 2009). All these approaches can be implemented solely or multi-disciplinary to complement fisheries management. Most resource management agreements, conventions, and guidelines stress the importance of a collaborative and participatory form of management. For example, the ecosystem-management, rights-based approaches, and resilience perspectives are compatible with each other. (Bene et al., 2019)

Frameworks and policies have been put in place to provide guidelines on how fisheries are managed. In 1995, FAO introduced a general fishery policy and management cycle with a number of activities that scale down from international laws and policies to national governance issues to operational management of fisheries (Andrew et al, 2003). Despite the approaches and well-planned frameworks, the capacity of small-scale fishers in developing countries to conduct assessments and to monitor and evaluate the outcome is limited.

The overall management strategy for fisheries resources in Zimbabwe is sustainable utilization and maintenance of biological diversity. The overall aim is to increase production so as to strengthen the rural economy, create employment, and enhance household food security (FAO, 2007). Fisheries management regulations are enacted within the National Parks Act of 1975 (Parks and Wildlife Act–Chapter 20:14 of 1996, as amended). This is the principal legislation and management Act governing the development, control, and management of fisheries in Zimbabwe. Part XIV of the Act deals with fish conservation. The regulations focus on license limitation, gear

and area restriction, and controlling mesh size and number of nets allowed per fisher as a regulatory effort. (FAO, 2007).

Fishing in Zimbabwe is controlled and only allowed in specified waters. Fishing is carried out after issuance of a permit by the appropriate authority. Catching and selling fish requires a permit. Possession of fishing nets is only allowed for fishing-net manufacturers or holders of valid fishing permits. On private land (waters), the appropriate authority may possess a fishing permit. The registration as a dealer or manufacturer of fishing nets is only granted and authorized by the Minister of Environment and Tourism through the provisions of the Parks and Wildlife Act, while the fishing gear for each controlled fish water body is specified in the Parks and Wildlife Act (FAO, 2007).

There was the introduction of fishery co-management within the inshore fishery. Its objective is to reduce conflicts between fishers and resource managers by bringing in fishers' participatory management. A good example was set at Lake Kariba fisheries (FAO, 2007). Provisions of co-management are in a legal framework – section 95(1) of the National Parks Act of 1991 and 1994 (SI 12/91 and SI 40/94 respectively) allows for devolution of appropriate authority to district councils who then sublease exclusive fishing zones to local fishing communities. Typically, there was the provision of a Kariba Lakeshore Combination Master Plan where the fishing grounds were zoned and assigned to specific fisher groups. Fishers were assisted in establishing fisheries management institutions, to formulate constitutions, and were trained in necessary skills. The success of the co-management initiative on Lake Kariba has not yet been evaluated. It is anticipated that if the system is effective, it may be introduced on other reservoirs (Mzingwane, 2020).

Production and management strategies have been employed at Lake Kariba, aiming for sustainable exploitation that ensures conservation of the fish genetic resource. However, fisheries management has been declining due to a number of factors. (Nhiwatiwa,2020). Zimbabwe should formalize co-management councils and revive indigenous knowledge systems in policy-making.

2.5 Small-scale fishing operations in Zimbabwe

As a landlocked country, Zimbabwe has inland fishery resources. There are a number of man-made lakes such as Kariba, Mutirikwi, Chivero, Manyame, Sebakwe, Osborne, and Darwendale. However, the country's full potential to support small-scale fishing has not been fully realized. A study was carried out on Lake Mutirikwi, looking at the importance of small-scale fishing in

supporting the livelihoods of the fishers on the lake (Gwazani et al,2022). The study was aimed at determining the annual fish production and economic value of the fishery, as well as the economic characteristics of the Fishers on Lake Mutirikwi. Fisheries on Lake Mutirikwi are important to both the national and household levels. At the national level, annual fish production from the fisheries contributes to the national fish production. At the household level, fishing provides a livelihood option for both full-time and part-time fishers; it has also managed to generate employment and income for fishing households at Lake Mutirikwi.

An article by Muringai et al. (2020) assessed both climate change–induced and non-climate-related challenges based on the experiences of gillnet small-scale fishers in the Sanyati fishing basin of Lake Kariba, Zimbabwe. The study results showed that declining fish catches are one of the major challenges experienced by fishers. The main themes that emanated as the challenges faced by fishers are food insecurity, wildlife attacks, lack of access to information systems, lack of fishing equipment, the existence of the predator crayfish, poor lake co-management, and shrinking fishing boundaries. Overall, the study found that fish production is negatively affected by several political, economic, and environmental factors; therefore, development through the public and private organizations should incorporate small-scale fishers in policy formulation to positively enhance livelihoods and food security (Muringai et al, 2019). The impacts of climate change, such as rising global average temperature and changes in precipitation patterns, are already affecting ecosystems, biodiversity, and human systems throughout the world (Kotir, 2011). Barange et al. (2018) demonstrated that climate change adversely affects small-scale fishers through reduced fish production and damage to fishing infrastructure, largely driven by the increasing occurrence of extreme weather events, including floods, cyclones, and droughts.

Research was conducted in Northern Zimbabwe on how communities access and evaluate inland fisheries and their influence on the conservation status (Utete et al, 2022). Results of the study showed that locals utilized 17 fish species for social, economic, cultural, and religious purposes. Locals attach high intrinsic socio-economic value to fisheries resources and wetland ecosystem services provided by the Mushumbi Pools. Despite the sustained income from fisheries, the local market in Mushumbi pools is actually undervaluing the fish resources, as the fish prices in the area are very low compared to market prices countywide (Utete et al, 2022).

A survey was conducted in three districts namely Chivi, Masvingo and Gutu of Masvingo province to assess rural small-scale fish farmers' perception and technical efficiency. Fish farming system was done in earthen ponds stocked with mixed-sex tilapia fingerlings, collected mainly from the wild and fed mostly on local farm by-products. The Cobb-Douglas production function was applied to relate production output to input variables (FAO,2020). Results indicated a significant positive correlation between the production output and the quantity of fingerling and feed inputs. Pond size had an inverse relation with production output. Gwazani et al. (2022) found that fingerling and fish feed quality significantly reduced technical inefficiency. In contrast, time allocated to fish farming and level of education had no significant effect. Farming experience significantly increased technical inefficiency, while age, training, gender, and occupation had no significant influence. Overall, fish farmers were operating at 67% technical efficiency.

Small-scale fishing is an important source of livelihood for millions of people globally, specifically in sub-Saharan Africa. These fishing operations locally often serve as primary sources of food and income, especially in rural communities (Béné, 2003). Darwendale Dam, located in Zimbabwe, has become an important site for small-scale fishing, with local communities depending on it for both subsistence and income generation. This study aimed at investigating the socio-economic contributions of small-scale fishing at Darwendale Dam, the challenges faced by these operations, and the management practices at the place.

CHAPTER 3: MATERIALS AND METHODS

3.1 Study area

The study was carried out at Darwendale Dam, also known as Lake Manyame, a man-made reservoir located in Mashonaland West Province, Zimbabwe (Figure 1). The dam was established in 1956 and has a surface area of approximately 78 km², with a storage capacity of about 490 million cubic metres (Zimbabwe Parks and Wildlife Management Authority, 2020).

Physically, the study area is characterized by a subtropical climate with distinct wet (November–March) and dry (April–October) seasons, which strongly influence water levels and fish productivity. The reservoir is relatively shallow with fluctuating water levels, particularly during drought periods, affecting fish habitats and fishing activities. The surrounding area is dominated by Miombo woodland vegetation, interspersed with grasslands and agricultural land. The dam supports a diversity of aquatic species, including commercially important fish such as tilapia (*O. niloticus*.) and catfish (*C. gariepinus*).

The study area was selected primarily due to its significant contribution to fish supply by small-scale fishing communities to surrounding areas, including Zvimba, Norton, and Nyabira. Local communities rely heavily on the dam for both fishing and agriculture. In addition, the dam serves as a recreational site, supporting activities such as nature walks, bird watching, water sports, hiking, and wildlife photography.

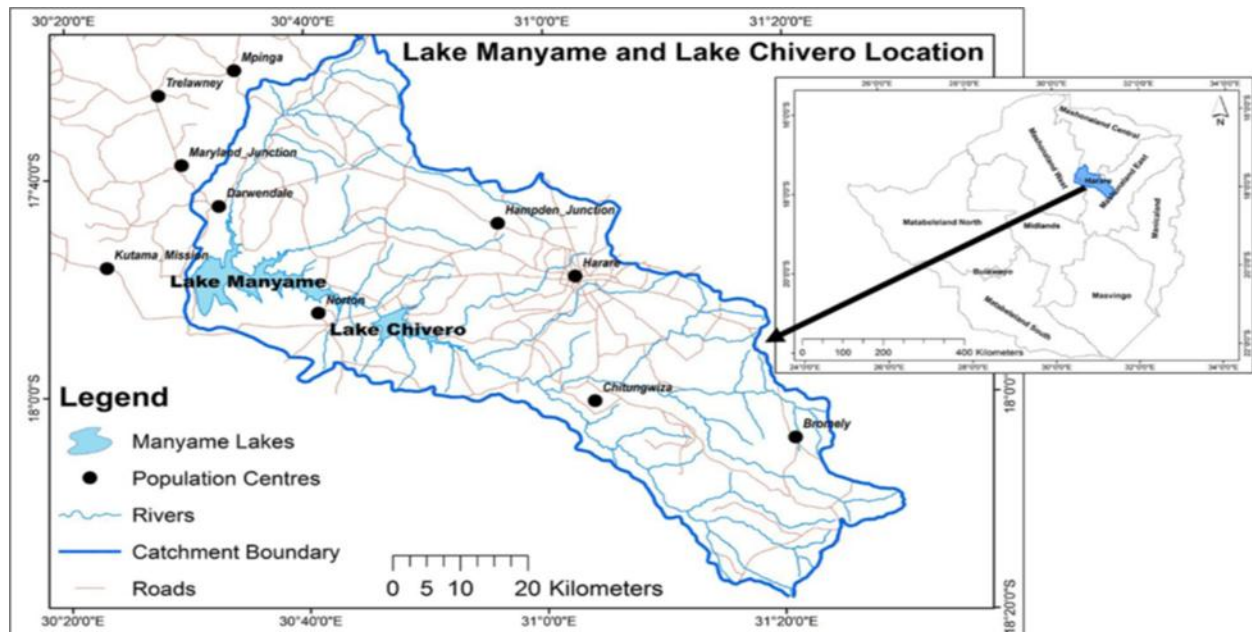


Figure 1: Location of study area— Darwendale dam, also known as Lakes Manyame in Zimbabwe

3.2 Research Design

The study adopted a descriptive survey using a mixed-methods approach to examine different but interrelated aspects of the small-scale fishery system. Quantitative methods were applied to biophysical and production-related components, specifically fish catch volumes, species composition, and selected environmental parameters, as these aspects require numerical measurement to identify patterns, trends, and variations across seasons and fishing groups. In contrast, qualitative methods were used to investigate the human and institutional dimensions of the fishery, including fishing practices, livelihood challenges, compliance behaviour, and governance arrangements, which are best understood through stakeholders' experiences and perceptions. Each method therefore addressed a distinct dimension of the socio-ecological system while remaining analytically connected. Integration occurred at the interpretation stage, where quantitative trends (such as declining catches or species shifts) were examined alongside qualitative explanations provided by fishers and authorities. This complementary use of methods enabled triangulation across ecological, socio-economic, and governance data, strengthening the credibility of the findings by ensuring that statistical results were supported and explained by contextual, experiential evidence, thereby improving both reliability and validity of the study outcomes.

3.2.1 Target Population

The target population comprises small-scale fishers operating at Darwendale Dam, local fish traders, Zimbabwe Parks and Wildlife Management Authority (ZPWMA) officials, and ‘community leaders’. These stakeholders are directly or indirectly involved in the management, exploitation, and monitoring of the fisheries at Darwendale dam.

3.2.2 Sampling

The study employed a mixed sampling strategy comprising purposive and stratified random sampling. Purposive sampling was used to select 4 key informants who met clearly defined qualifying attributes, namely: formal responsibility for fisheries management at Darwendale Dam (ZPWMA officials), and recognised leadership roles within fishing communities (community leaders). These informants were selected based on their direct involvement in regulation, enforcement, and community coordination. Stratified random sampling was applied to 3 small-scale fishers per group to ensure representation across predefined strata. Fishing methods were not used as a stratification criterion, as they constitute a key variable investigated in the study. The final sample size was 50 participants, comprising 40 small-scale fishers, 4 fish traders, 2 ZPWMA officials, and 4 community leaders. This sample size was sufficient to generate reliable quantitative patterns and rich qualitative insights aligned with all research objectives.

3.3 Research Procedure

Data were collected through observations, questionnaires, and interviews conducted during the fieldwork period. Rather than collecting data continuously over an entire year, respondents were asked to report on fishing activities, catch patterns, and environmental conditions they experienced over the preceding twelve-month period (January to December, 2025). This approach enabled the study to capture seasonal variations in fishing operations, species availability, and environmental conditions based on fishers’ knowledge and institutional records. The use of recall-based information allowed assessment of changes across different periods of the year, including wet and dry seasons, without requiring year-long field presence. Both quantitative data (e.g., estimated catch volumes, species composition, and frequency of fishing activities) and qualitative data were collected. Quantitative data were obtained through structured questionnaires administered to fishers and supplemented by catch records where available. Qualitative data on seasonal changes and challenges were elicited using semi-structured interviews and focus group discussions, which

allowed fishers to describe their experiences of temporal variations in fish availability, water levels, and weather patterns, as well as the constraints affecting their fishing activities.

This mixed-methods approach enabled triangulation of data sources, enhancing the reliability of findings and providing a comprehensive understanding of the dynamics of small-scale fishing operations at Darwendale Dam, while remaining feasible within the study's time and resource constraints.

3.3.1 Water quality assessment

Water quality information for this study was obtained from two sources: secondary data from the Environmental Management Agency (EMA), accessed through ZimParks officials, and primary field measurements conducted by the researcher. EMA routinely collects water samples at Darwendale Dam as part of its regulatory monitoring programme and provided secondary data on selected physical parameters, namely temperature (°C), turbidity (NTU), and dissolved oxygen (mg/L), which are measured thrice per year. These parameters were obtained as numerical values from institutional records and were used to provide baseline environmental conditions for the dam.

In addition, the study conducted primary water quality assessments to complement the socio-economic and ecological data collected from fishers and stakeholders. All measurements were carried out *in situ* using portable field instruments. Water temperature (°C) was measured using a calibrated digital thermometer integrated within a multipara meter probe. The pH was determined using a portable pH meter calibrated with standard buffer solutions prior to measurement. Dissolved oxygen (mg/L) was measured using a portable dissolved oxygen meter based on an electrochemical probe method. Electrical conductivity (µS/cm) was measured using a handheld conductivity meter.

Turbidity (NTU) was measured using a portable turbidity meter, which estimates the scattering of light by suspended particles. Nutrient concentrations, including nitrates and phosphates (mg/L), were determined using portable water testing kits based on colorimetric methods, with results interpreted according to manufacturer guidelines. Together, the primary and secondary datasets enabled interpretation of ecological conditions and their potential influence on fish productivity and spatial distribution at Darwendale Dam.

3.4 Data Collection

The questionnaires collected both quantitative and qualitative data structured into clearly defined categories. Quantitative data included: (i) demographic variables of the fishermen recorded included; age (years), gender (male/female), fishing experience (years), and cooperative membership (member/non-member); (ii) fishing effort and practices—type of fishing gear used (gillnets, lines and hooks, spears), number of nets owned, mesh size used (inches), fishing frequency (days fished per week), and fishing duration (hours per trip); (iii) production data—estimated catch quantities expressed as kilograms per day, per month, and per year, and frequency of species caught (number of times each species was reported); and (iv) livelihood and economic variables—sources of start-up capital, average monthly income from fishing, savings or investment status (yes/no), and proportion of household income derived from fishing (%). Frequencies were calculated for gear types used, species caught, cooperative membership, enforcement encounters, and reported challenges. Likert-scale items (1–5) measured perceptions of environmental change, governance effectiveness, and market stability.

Qualitative questionnaire data, expressed thematically, were derived from open-ended responses on perceived environmental pressures, seasonal changes in fish availability, regulatory challenges, livelihood constraints, and support needs.

Interviews generated in-depth qualitative data, recorded as textual transcripts and analysed thematically. These focused on governance structures, enforcement capacity, institutional support, policy gaps, historical trends in catches and species composition, environmental threats, and community-based management initiatives.

Together, questionnaire data, interview narratives, and water-quality measurements provided a triangulated understanding of ecological, socio-economic, and governance dynamics shaping small-scale fisheries at Darwendale Dam.

3.5 Data Analysis

Data on small-scale fishing operations were analysed using descriptive and inferential statistical techniques. Descriptive statistics were applied to clearly defined variables derived from the questionnaire dataset. Frequencies and percentages were calculated for categorical variables, including types of fishing gear used (gillnets, lines and hooks, and spears), species caught (*O.*

niloticus, *C. gariepinus*, *C. carpio*, *M. salmoides*, *L. altivelis* and *T. sparrmanii*), cooperative membership status, and reported fishing challenges.

Means and standard deviations were computed for continuous numerical variables, specifically catch quantities expressed in kilograms per day, per month, and per year, age of fishers (years), and years of fishing experience. Variation in catch quantities was measured in relation to the fishers' age and fishing experience to identify patterns in fishing productivity across different fisher profiles.

Data were presented using tables, bar charts, pie charts, and line graphs, while photographs from field observations illustrated fishing vessels, gear types, and landing practices. In addition, a One-Way Analysis of Variance (ANOVA) was conducted to test whether mean catch weights (kg) differ significantly among the major fish species recorded at Darwendale Dam.

Qualitative data obtained from open-ended questionnaire responses, key informant interviews, and field observations were analysed using thematic content analysis. All interview responses were transcribed verbatim and repeatedly reviewed to ensure familiarity with the data. An inductive coding approach was applied, whereby meaningful statements were assigned initial codes reflecting participants' perceptions and experiences. Similar codes were then grouped into broader themes that aligned with the study objectives, including fishing practices, environmental pressures, governance effectiveness, compliance behaviour, and livelihood challenges. Direct quotations were used selectively in the results chapter to illustrate dominant themes and to preserve participants' voices. Triangulation was achieved by comparing responses from fishers, traders, community leaders, and ZimParks officials, thereby enhancing credibility and reducing respondent bias.

Policy analysis reviewed fisheries management frameworks governing Darwendale Dam through document analysis of the Parks and Wildlife Act (Chapter 20:14), ZimParks regulations, and fisheries permit guidelines. Policies on access control, gear restrictions, enforcement, and stakeholder participation were assessed against field findings to identify implementation gaps, enforcement challenges, and opportunities for community-based co-management. This approach provided an understanding of the governance of small-scale fishing operations at Darwendale Dam.

CHAPTER FOUR: RESULTS

4.1 Demographics of the respondents

A total of 50 respondents participated in the study, representing a 100% response rate.

4.1.2. Reliability Test

Table 4.1: Reliability Statistics

Construct	Number of Items	Cronbach's Alpha
Fishing Methods & Practices	6	0.79
Catch Trends & Species Composition	5	0.82
Environmental Influences	7	0.76
Governance & Management	6	0.81
Challenges & Opportunities	8	0.84
Overall Instrument	32	0.83

The reliability results indicate that the research instrument demonstrated strong internal consistency across all measured constructs. Cronbach's Alpha values ranged from 0.76 to 0.84, exceeding the commonly accepted threshold of 0.70 for social science research. This suggests that items within each construct—such as fishing methods, catch trends, environmental influences, governance, and challenges—were closely related and measured the same underlying concept effectively. The overall reliability score of 0.83 confirms that the combined instrument was highly dependable and suitable for analyzing perceptions and experiences of participants. High reliability also implies that respondents interpreted questionnaire items consistently, reducing measurement error and increasing confidence in the stability and accuracy of the data. Consequently, the tool used in this study can be considered both robust and appropriate for assessing small-scale fisheries dynamics at Darwendale Dam.

Table 4.2: Fishing Experience of Participants.

Fishing Experience	Frequency of general participants	Percentage
Less than 1 year	7	14
1–5 years	10	20
6–10 years	12	24
More than 10 years	21	42

While 14% are newcomers with less than one year of experience, the majority (66%) have more than five years of involvement, and 42% have over a decade of fishing activity. This indicates a mature fishing community with deep local ecological knowledge, which may influence gear selection, species targeting, and adaptive strategies. The presence of experienced fishers also suggests strong dependence on the dam as a long-term livelihood source, reinforcing the importance of sustainable management interventions.

4.2 Fishing methods used at Darwendale Dam

The study identified three categories of fishers operating at Darwendale Dam: registered cooperative fishers, registered individual fishers, and unregistered individual fishers. Across these categories, the research established three main fishing methods: gillnets, fishing lines and hooks, and spears.

Gillnets used at the dam varied in net length and mesh size. Net lengths ranged between 300 m and 600 m. Mesh sizes recorded included ≥ 3.5 inches, which conforms to the ZimParks standard, as well as 4 to 5 inches, which exceed the recommended specification. Cooperative fishers consistently used standardised gillnets measuring 3.5-inch mesh size with a length of 533.3 m, as stipulated by ZimParks. Registered individual fishers used gillnets and fishing lines and hooks, while unregistered fishers used gillnets and spears, with mesh sizes exceeding the standard.

Across all fisher categories, based on the number of respondents reporting each method, gillnets emerged as the most commonly used fishing method (Fig 2), followed by fishing lines and hooks,

while spear fishing was least used. All categories of fishers utilised boats and canoes as fishing vessels, as fishing from the shoreline was not feasible due to depth and vegetation cover.

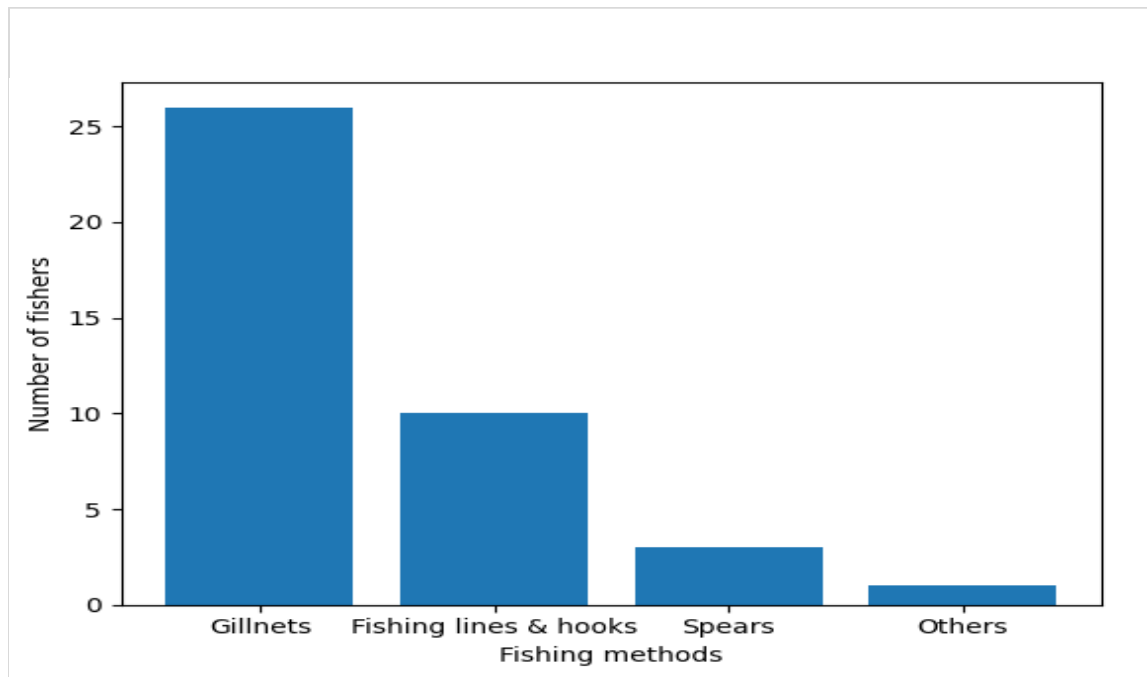


Figure 2: Bar showing the number of respondents who reported to be using the different fishing methods



Figure 2: A, B and C shows fishing vessels, gillnets and fishing vessels inside the dam, respectively

4.3 Types of fish types and quantities caught by small scale fishers in Darwendale dam.

Seven species of fish are harvested at Darwendale Dam (Table 4.4).

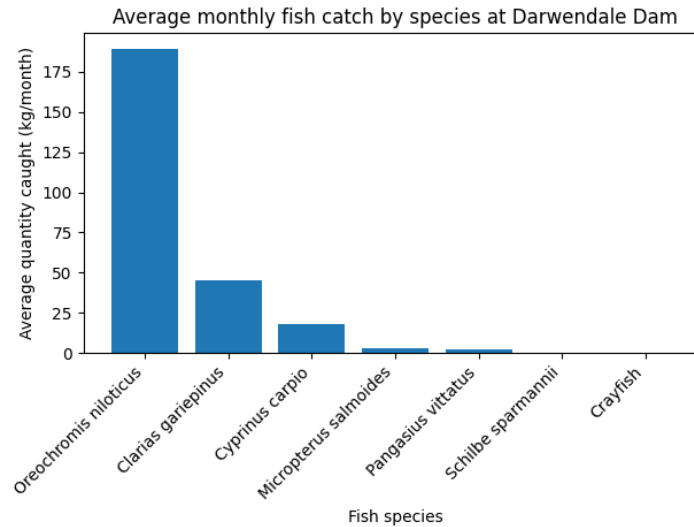


Figure .3: average monthly quantities of fish species caught by small-scale fishers at Darwendale Dam

Figure 4.4 illustrates the average monthly quantities of fish of each species caught by small-scale fishers at Darwendale Dam, expressed in kilograms per month that is from January to December. The results show a clear dominance of *O. niloticus* (bream), which accounts for the highest proportion of the catch, indicating that it is the most abundant and frequently targeted species in the dam. *C. gariepinus* (sharp tooth catfish) is the second most harvested species, followed by *C. carpio* (common carp), though at considerably lower quantities. Other species, including *M. salmoides* (largemouth bass), *P. vittatus* (striped catfish), and *S. sparmannii* (silver catfish), contribute minimally to total catches, suggesting lower abundance or reduced catchability. Crayfish appear in very small quantities, reflecting either limited harvesting or low integration into fishing practices despite their invasive presence. Overall, the graph demonstrates a skewed catch composition dominated by a few species, highlighting patterns of species availability and fishing selectivity at Darwendale Dam.



Figure 5: Showing fish types caught at Darwendale dam (4) Nilotica, bass, fish, Gariepinus and crayfish (5) Nilotica, catfish and Gariepinus

Table 4.3: One-Way ANOVA Comparing Mean Catch Across Species

The table below presents the results of a one – way ANOVA used to test for differences in mean catch among dominant species. The analysis yielded an F- value of 0.224 with a corresponding p– value of 0.925. Since the p value is greater than the pre-set significance level of $\alpha=0.05$, we fail to reject the null hypothesis. This indicates there is no statistically significant difference in mean catch across the dominant species included in this analysis.

Statistic	Value
F-value	0.224
p-value	0.925
Significance Level (α)	0.05
Decision	Fail to Reject H_0

Note: Only dominant species with sufficient observations were included; less frequent species were excluded due to inadequate sample sizes for valid ANOVA assumptions.

The One-Way ANOVA indicates no statistically significant difference in mean daily catch weights among *O. niloticus*, *C. gariepinus*, and *Cyprinus carpio* ($F = 0.224$, $p = 0.925$, $\alpha = 0.05$). This

result reflects that *O. niloticus* had the highest catch per-day catch rates per fisher, despite large differences in total monthly catch volumes observed across species. The apparent dominance of *O. niloticus* in monthly production is therefore attributed to higher availability and fishing frequency, rather than higher daily catch efficiency. The analysis is exploratory and should be interpreted with caution due to high differences within-species variability.

4.4 Environmental factors influencing fish population in Darwendale dam

Analysis of qualitative interview transcripts and questionnaire responses using thematic coding revealed four dominant environmental themes influencing fish populations and catch efficiency: pollution, seasonal water-level fluctuations, invasive species, and weed overgrowth. These themes emerged inductively from respondents' accounts and were supported by quantitative water-quality data.

4.4.1 Pollution

Water quality analysis revealed variable compliance with the Environmental Management (Effluent and Solid Waste Disposal) Regulations SI 6 of 2007, with several sampling sites classified under the non-compliant (red) band. Notably, red band conditions were recorded at Point 2 Center (15 m), Geneva Bay (5 m), Area 7 Bay (10 m), Gomba Dam (multiple depths), and Manyame Mouth, while a few sites such as Point 1 Center (0 m and 5 m) and Area 7 Bay (0–5 m) fell within the permissible (green) category. Key parameters exceeding regulatory limits included turbidity, which reached 5178 NTU at Point 2 Center (15 m), and total suspended solids (TSS), which peaked at 32,800 mg/L at the same location. Phosphate concentrations were highest at Area 7 Bay (10 m) (188 mg/L), while total dissolved solids (TDS) reached 9636 mg/L at Gomba Dam (0 m). Elevated concentrations of heavy metals were also recorded, including iron (64.82 mg/L) and manganese (6.12 mg/L) at Geneva Bay (5 m), and copper (20.5 mg/L) at Point 2 Center (15 m), all exceeding permissible thresholds. Spatially, higher pollution levels were generally observed in deeper sampling points and inflow-influenced areas, whereas surface and nearshore locations tended to exhibit comparatively better water quality (EMA data produced by ZimParks, 2025)

These observations are supported by water-quality measurements recorded during the rainy season (December–March), when surface runoff into Darwendale Dam is highest. Data were obtained from ZimParks routine monitoring records and field measurements conducted by the

Environmental Management Agency (EMA) shortly after rainfall events, a period known to reflect peak inputs of sediments and dissolved substances from the catchment.

During this period, moderate turbidity values (2.78 NTU) were recorded, indicating increased suspended particles associated with runoff. The water exhibited a slightly alkaline pH (8.5) and elevated electrical conductivity (546 $\mu\text{S}/\text{cm}$), reflecting increased dissolved ions likely originating from agricultural runoff and surrounding human activities. Nitrate ($<2 \text{ mg/L}$) and phosphate ($<0.1 \text{ mg/L}$) concentrations confirm nutrient inputs into the dam, while mean dissolved oxygen levels of 4.7 mg/L , although not critically low, approach thresholds that may induce physiological stress in more oxygen-sensitive fish species.

The physio-chemical conditions observed in Darwendale Dam have important implications for fish distribution, abundance, and overall ecosystem productivity. Water quality parameters such as dissolved oxygen, temperature, turbidity, pH, and nutrient concentrations directly affect the physiological functioning, behaviour, and survival of fish species. Variations in these conditions can alter habitat suitability, influence feeding patterns, and affect reproductive success.

Dissolved oxygen is one of the most critical factors regulating fish populations. Low oxygen concentrations restrict aerobic respiration, causing physiological stress and reducing growth, feeding activity, and reproductive performance. Fish species that are less tolerant of oxygen depletion may migrate to areas with higher oxygen levels, resulting in uneven spatial distribution within the dam. Such movements can reduce catch rates in certain fishing grounds and may force fishers to travel further to locate productive fishing areas. Species that are highly sensitive to low oxygen levels may experience population declines if stressful conditions persist for extended periods.

Turbidity also plays a significant role in shaping fish communities. Increased turbidity reduces water clarity and limits light penetration into deeper layers of the water column. Reduced light availability can decrease photosynthetic activity by aquatic plants and phytoplankton, ultimately affecting the food web that supports fish populations. High turbidity may also interfere with the ability of visually oriented predators, such as bass and tilapia, to locate prey, thereby altering feeding efficiency and growth rates. However, some fish species may benefit from moderate turbidity because it provides protection from predators and reduces competition.

Nutrient enrichment, particularly from nitrogen and phosphorus compounds, can stimulate excessive growth of aquatic vegetation and algae. Although moderate nutrient levels can enhance fish production by increasing food availability, excessive nutrient loading may lead to eutrophication. Dense growth of aquatic weeds can restrict fish movement, reduce the extent of open-water habitats, and interfere with fishing operations. Furthermore, decomposition of excessive plant and algal biomass can consume dissolved oxygen, creating conditions that are unfavourable for many fish species.

Water temperature influences metabolic processes, feeding rates, growth, and reproduction. Elevated temperatures generally increase metabolic demands, causing fish to require more oxygen at a time when warm water naturally holds less dissolved oxygen. This interaction can place additional stress on fish populations, especially during warmer months. Similarly, pH levels outside the optimal range can affect physiological processes, reduce reproductive success, and increase susceptibility to disease.

The combined effects of these physio-chemical factors can lead to shifts in fish distribution and species composition within Darwendale Dam. Fish often concentrate in deeper, cooler, or less-disturbed areas where environmental conditions are more favourable. Such redistribution may explain fishers' observations of declining catches in some locations and changes in the types of fish being caught. Therefore, maintaining suitable water quality conditions is essential for sustaining healthy fish populations, supporting fish productivity, and ensuring the long-term viability of small-scale fisheries in Darwendale Dam.

Table 4.4: Summaries of the data were provided by ZimParks from their yearly reports from EMA : Physicochemical Water Quality Parameters

Parameter	Observed Value	Unit
Turbidity	2,783.3	NTU
Temperature	27	°C
pH	8.5	–
Dissolved Oxygen (DO)	47	mg/L
Electrical Conductivity (EC)	546	µS/cm
Nitrates (NO ₃ ⁻)	< 2	mg/L
Phosphates (PO ₄ ³⁻)	< 0.1	mg/L

The ZimParks official provided the data on water parameters. The measured physicochemical parameters provide important insight into the condition of the aquatic environment. Turbidity was extremely high (2,783.3 NTU), indicating a substantial presence of suspended particles such as silt, clay, and organic matter, likely resulting from surface runoff, erosion, and sediment disturbance, particularly after rainfall events. Such elevated turbidity reduces light penetration, limits photosynthesis, and can impair fish health by clogging gills. The recorded water temperature of 27°C falls within the typical range for tropical freshwater ecosystems and is generally suitable for the survival and growth of most fish species. However, elevated temperatures can reduce the solubility of oxygen in water, resulting in lower dissolved oxygen availability for aquatic organisms. Higher temperatures also increase the metabolic rates of fish, leading to greater oxygen demand. If oxygen levels become insufficient, fish may experience physiological stress, reduced feeding activity, slower growth rates, and increased susceptibility to diseases. In extreme cases, prolonged exposure to high temperatures may alter fish distribution patterns as individuals seek cooler and more oxygen-rich habitats within the dam.

The pH value of 8.5 indicates slightly alkaline water conditions. Most freshwater fish species can tolerate a pH range of approximately 6.5 to 9.0; therefore, the recorded value is generally

considered favourable for aquatic life. Slightly alkaline conditions may support biological productivity and nutrient availability within the aquatic ecosystem. However, pH plays a significant role in determining the chemical behaviour and toxicity of certain substances in water. At higher pH levels, compounds such as ammonia become more toxic to fish and other aquatic organisms. Consequently, if nutrient enrichment or organic pollution occurs, the potential negative effects of toxic compounds may be amplified under alkaline conditions. Overall, the recorded pH suggests that the water quality is suitable for sustaining fish populations, although continuous monitoring is important to detect any changes that could affect aquatic ecosystem health. Dissolved oxygen was reported as 47 mg/L, which is unusually high for natural waters and suggests a possible measurement or unit error, as typical values rarely exceed 14 mg/L; this value therefore requires verification. Electrical conductivity (546 $\mu\text{S}/\text{cm}$) indicates a moderate level of dissolved ions, likely originating from natural mineral sources or anthropogenic inputs such as agricultural runoff. Nutrient concentrations were relatively low, with nitrates recorded at less than 2 mg/L and phosphates at less than 0.1 mg/L, suggesting limited nutrient pollution and a low risk of eutrophication at the time of sampling. Overall, the results point to a system affected primarily by high sediment loads rather than nutrient enrichment,

4.4.2: Effect of Seasonal Changes in Water Levels

Participants were also asked: *“Have you observed any changes in fish catch that relate to seasons or water levels?”* Responses revealed strong awareness of seasonal changes in dam water levels as a determinant of fish populations and catch outcomes. One respondent explained, *“When water levels go down, the fish move far into deeper places and we catch less.”* Another added, *“During the rainy season, we see more small fish, but when it is dry, the size reduces because the water becomes hot and shallow.”*

4.4.3: Invasive Species.

Results from interviews with small-scale fishers at Darwendale Dam indicated the presence of several invasive species, including both aquatic weeds and crayfish. Fishers commonly reported the occurrence of water weeds, which they described as spreading rapidly in certain fishing areas and interfering with fishing activities. Although most respondents identified these weeds using local names, their descriptions correspond to known invasive aquatic plant species such as *Eichhornia crassipes* (water hyacinth) and *Salvinia molesta* (giant salvinia).

In addition, a number of fishers reported the presence of crayfish in the dam, which they identified as a relatively recent occurrence. Respondents noted that crayfish are frequently caught in nets and traps, sometimes in significant numbers. While some fishers indicated that crayfish can be used for consumption or sale, the majority expressed concern over their negative impacts. These included damage to fishing nets, increased effort required to sort catches, and potential reduction in fish catches.

Fishers further reported that invasive weeds obstruct access to fishing grounds, entangle fishing gear, and reduce the efficiency of fishing operations. Similarly, crayfish were perceived to affect the aquatic environment through their feeding and burrowing behaviour, although most observations were based on experience rather than scientific knowledge.

To understand biological pressures on fish populations, participants were asked: *“Are there any invasive plants or animals in the dam that you think affect fishing or fish availability?”* This question elicited strong reactions. One fisher stated, *“Water hyacinth is taking over some areas, and when it covers the water, we cannot fish and the fish hide under it.”* A ZimParks official emphasised the expanding presence of crayfish, remarking, *“The crayfish population is increasing and they disturb nets and feed on fish eggs.”*

The narratives confirm that invasive species are among the most disruptive ecological challenges in the dam. Water hyacinth creates dense mats that limit light penetration, reduce dissolved oxygen, and impede movement of boats and nets. The participants’ observation that fish “hide under the weeds” reflects behavioural responses to altered microhabitats.

4.4.4: Water hyacinth and Its Effects on Fishing Efficiency

Participants were also asked: *“How does weed growth in the dam affect your fishing activities?”* Responses were unanimous. One fisher explained, *“Weeds make it difficult to set nets because they get tangled, and sometimes we lose nets in thick areas.”* Another respondent added, *“The fish stay inside the weeds and it is difficult to catch them, even when we know they are there.”*

Weed overgrowth emerged as both a biological and operational challenge. Dense macrophytes reduce catch efficiency by providing refuge for fish, obstructing gear deployment, and increasing labour time. The respondent accounts reflect first-hand experiences of these ecological processes,

reinforcing the interconnectedness between water quality, vegetation dynamics, and fisheries productivity. Officials further indicated that weed proliferation has accelerated in recent years

4.5 The Management Framework and Policies Regulating Fishing Operations

The study first examined the existing policies, regulatory instruments, and governance structures guiding small-scale fishing operations at Darwendale Dam. Results show that a formal management framework is in place, primarily administered by ZimParks, with support from community fisheries committees. Key regulations reported include net mesh-size limits, restrictions on fishing gear, designated fishing zones, closed areas, and permit requirements. These instruments constitute the official framework intended to regulate access and promote sustainable exploitation of fish resources.

Findings revealed that adherence to regulations is constrained by enforcement limitations rather than unwillingness to comply. Fishers consistently reported infrequent patrols and limited surveillance, which enable illegal activities to persist. One respondent explained, *“There are few patrols, so poachers take advantage, and sometimes they steal our nets”* (F14). This was corroborated by institutional perspectives, with a ZimParks official stating, *“We do not have enough equipment or manpower to patrol the whole dam consistently”* (ZP02). These responses highlight a mismatch between regulatory expectations and enforcement capacity.

Registered fishers generally expressed support for permit systems and gear restrictions, viewing them as necessary for reducing pressure on fish stocks. Nonetheless, inconsistent enforcement was a recurrent concern. One fisher remarked, *“Sometimes rules apply only when inspectors come, but other times poachers do whatever they want”* (F33). Such inconsistencies were reported to undermine trust in management institutions and weaken compliance incentives.

Participants also noted that weed overgrowth complicates enforcement, as dense vegetation conceals illegal fishing activities and restricts patrol access. Several respondents suggested that improved coordination between ZimParks and fishing cooperatives could enhance monitoring and control in these areas. Overall, the results indicate that while policies and management frameworks exist and are widely known, their effectiveness is limited by resource constraints, environmental pressures, and insufficient stakeholder involvement in enforcement.

4.6 Challenges and Opportunities Faced by Small-Scale Fishers

Building on the governance context presented above, this section examines the socio-economic, environmental, and institutional challenges experienced by small-scale fishers at Darwendale Dam, as well as emerging opportunities that could enhance their resilience and participation in sustainable fisheries management. Analysis of qualitative interview transcripts and open-ended questionnaire responses revealed six dominant challenge themes: poor infrastructure, pollution and weed invasion, theft of fishing equipment, unstable markets, competition and overfishing, and inconsistent enforcement.

Poor infrastructure was one of the most frequently reported challenges. Fishers highlighted the poor condition of access roads, particularly during the rainy season, which limits timely transportation of fish to markets. One fisher stated, *“The roads to the landing sites are very bad, especially when it rains, and sometimes we fail to reach the market on time”* (F06). Inadequate storage and lack of cold-chain facilities were also reported, leading to rapid spoilage of fish during hot periods. Several respondents indicated that this forces them to sell fish quickly at reduced prices, contributing to income instability.

Pollution and weed invasion were reported as persistent environmental challenges. Fishers noted that pollution from runoff and waste disposal degrades water quality, while invasive aquatic weeds obstruct fishing activities. One respondent remarked, *“The water gets dirty after rains and weeds grow everywhere, making fishing difficult”* (F18). Weed overgrowth was reported to entangle nets, damage gear, and provide refuge for fish, thereby reducing catch efficiency and increasing labour time.

Theft of fishing equipment emerged as a major livelihood threat. Many fishers reported losing gillnets, engines, and other gear, often during night-time operations. One fisher explained, *“Poachers steal our nets at night; sometimes you wake up and everything is gone”* (F27). The financial burden of replacing stolen equipment was described as severe, particularly for small-scale fishers with limited capital. Respondents linked theft to weak patrol presence and poor security around landing sites.

Unstable and limited markets were also widely reported. Fishers described fluctuating demand, lack of access to formal markets, and dependence on middlemen who dictate prices. One

participant noted, *“Sometimes the market is too small, and we are forced to sell fish cheaply to avoid losses”* (F11). Limited bargaining power and absence of organised marketing structures were reported to reduce profitability and discourage investment in better gear or vessels.

Competition and overfishing were perceived as growing pressures on fish stocks. Several respondents indicated that the number of fishers has increased over time, intensifying competition. One fisher stated, *“There are too many fishers now, and the catch is not the same as before”* (F31). The use of illegal methods by some fishers was reported to exacerbate stock depletion, particularly through the capture of juvenile fish.

Inconsistent enforcement of regulations was identified as a cross-cutting institutional challenge. Fishers reported irregular patrols and selective enforcement, which allow illegal fishing to persist. One respondent observed, *“Sometimes ZimParks comes, but most of the time poachers operate freely”* (F09). These inconsistencies were reported to undermine trust in management institutions and discourage compliance among law-abiding fishers.

Despite these challenges, the study identified a strong opportunity for community-driven co-management. Most fishers expressed willingness to collaborate with authorities in monitoring, reporting illegal activities, and managing environmental threats. One fisher stated, *“If they involve us more, we can help control poachers and manage weeds”* (F22). The presence of organised fishing cooperatives and community leaders provides a foundation for participatory governance approaches that could strengthen compliance, enhance enforcement, and improve long-term sustainability at Darwendale Dam.

CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

This study sought to examine small-scale fishing operations at Darwendale Dam by addressing fishing methods, species composition and catch quantities, environmental influences, governance frameworks, and socio-economic challenges. The findings reveal a complex socio-ecological system shaped by adaptive fishing practices, environmental pressures, and institutional constraints, consistent with patterns reported in inland fisheries across sub-Saharan Africa.

With regard to the first objective, which examined fishing methods used by small-scale fishers, the dominance of gillnets across all fisher categories reflects their efficiency and adaptability in multi-species inland fisheries. Gillnets are widely used in small-scale fisheries due to their low operational costs, ease of use, and effectiveness in capturing a wide range of species (FAO, 2019; Béné, 2006). Similar findings have been reported in Lake Kariba and Lake Mutirikwi, where gillnets constitute the primary fishing gear among artisanal fishers (Muringai et al., 2019; Gwazani et al., 2022). The variation in net mesh sizes observed at Darwendale Dam, particularly the use of larger-than-recommended meshes by unregistered fishers, aligns with studies showing that regulatory non-compliance often emerges where enforcement capacity is weak (Nhiwatiwa, 2020). The continued use of boats and canoes by all fisher categories further reflects the spatial characteristics of inland reservoirs, where shoreline fishing is constrained by depth and aquatic vegetation, a pattern also documented by Teh and Sumaila (2013).

The second objective, which focused on fish species composition and catch quantities, revealed a catch structure dominated by *O. niloticus*, followed by *C. gariepinus* and *Cyprinus carpio*. The dominance of *O. niloticus* can be partly attributed to its history of introduction into Zimbabwean water bodies, where it was widely stocked from the mid-20th century to enhance fish production in reservoirs (Marshall, 2011). Similarly, *C. carpio* was introduced for aquaculture and fisheries enhancement purposes, while *C. gariepinus* is indigenous to African freshwater systems and naturally occurs in many rivers and dams.

The observed dominance of tilapia species is consistent with findings from other Zimbabwean reservoirs, where *Oreochromis* species are favoured due to their rapid growth rates, high reproductive capacity, and tolerance to variable environmental conditions (Marshall, 2011; FAO, 2017). In addition, *O. niloticus* is highly adaptable to different feeding conditions and can exploit

a wide range of food resources, giving it a competitive advantage over other species. Its schooling behaviour and habitat use also make it more susceptible to capture using commonly used fishing gears such as gillnets, further contributing to its dominance in catches.

In contrast, the comparatively low quantities of species such as *M. salmoides* and *S. sparmannii* may be explained by a combination of ecological and fishery-related factors. *M. salmoides*, for instance, is a predatory species with lower population densities and is less vulnerable to capture by non-selective fishing gear. Similarly, *S. sparmannii* may be less abundant or occupy habitats that are less frequently exploited by fishers. These trends are often associated with habitat modification, interspecific competition, and sustained fishing pressure (Pauly et al., 2002).

The ANOVA results indicated no statistically significant differences in mean annual catch weights among dominant species, suggesting relatively uniform harvesting pressure. Similar observations have been made in small-scale fisheries where multi-gear use and non-selective fishing practices result in comparable catch rates across species (Béné et al., 2009). This finding may also reflect adaptive fisher behaviour, where effort is redistributed among available species in response to fluctuating stock availability.

Addressing the third objective, environmental factors influencing fish populations, the study found that pollution, seasonal water-level fluctuations, invasive species, and weed overgrowth significantly affect fishing productivity. Fishers' perceptions of pollution were corroborated by water-quality measurements showing moderate turbidity, elevated conductivity, and nutrient presence. Seasonal water-level fluctuations were perceived to influence fish movement and catch success, aligning with literature that links hydrological variability in reservoirs to changes in spawning behaviour and habitat availability (Welcomme et al., 2010). The reported impacts of invasive species and aquatic weeds are consistent with findings across African inland waters, where water hyacinth and invasive crayfish reduce fishing efficiency, damage gear, and disrupt breeding habitats (Virdin & Basurto, 2019). These environmental stressors collectively reflect broader ecosystem degradation challenges faced by small-scale fisheries under climate variability and land-use pressure (Barange et al., 2018).

The fourth objective, which examined governance structures and regulatory frameworks, revealed that while formal management systems exist at Darwendale Dam, their effectiveness is constrained by enforcement limitations. High awareness of regulations among fishers suggests that information

dissemination is not the primary governance challenge, a finding consistent with studies showing that compliance is more strongly influenced by enforcement credibility than by rule awareness alone (Ostrom, 1990; Andrew et al., 2007). Weak patrol capacity, limited resources, and inconsistent enforcement reported in this study mirror governance challenges documented in other Zimbabwean fisheries, particularly in smaller reservoirs where institutional oversight is fragmented (Donda, 2011; Nhiwatiwa, 2020). The gap between policy design and implementation reflects what Béné et al. (2010) describe as “institutional mismatch,” where regulatory frameworks exist on paper but lack operational support. The perceived unfairness arising from selective enforcement further undermines compliance, a phenomenon widely reported in small-scale fisheries governance literature (Jentoft, 2000).

Finally, the fifth objective, which explored socio-economic challenges and opportunities, revealed that fishers face interconnected livelihood constraints including poor infrastructure, theft, market instability, competition, and regulatory inconsistency. Poor infrastructure and lack of cold storage facilities have been widely cited as key barriers to income stability in artisanal fisheries, particularly in rural inland systems (IFAD, 2018; FAO, 2020). The prevalence of theft and gear loss reported in this study aligns with research showing that weak governance and open-access conditions increase conflict and insecurity in fisheries-dependent communities (Béné, 2003). Market instability and dependence on middlemen reflect broader structural inequalities within small-scale fisheries value chains, where fishers capture minimal value despite high labour input (Teh et al., 2013). Increased competition and perceptions of overfishing are consistent with Malthusian-type pressures described by Pauly (1997), where growing fisher numbers intensify exploitation of limited resources.

Despite these challenges, the strong willingness among fishers to engage in co-management represents a significant opportunity. Numerous studies have demonstrated that co-management arrangements enhance compliance, improve monitoring, and integrate local ecological knowledge into decision-making (Berkes, 2009; FAO, 2012). The presence of fishing cooperatives at Darwendale Dam provides an institutional foundation for such arrangements, echoing successful examples from Lake Kariba and other African inland fisheries (Vanden & Bernacsek, 1991). These findings suggest that participatory governance could address both enforcement gaps and socio-economic vulnerabilities if adequately supported.

5.2 Conclusion

The study examined small-scale fisheries at Darwendale Dam with the aim of understanding fishing methods, catch trends, environmental influences, governance frameworks, and socio-economic challenges faced by fishers. Results demonstrated that fishing activities are dominated by gillnets, reflecting the adaptive strategies fishers employ to optimise catch efficiency. Species composition analysis indicated that *Nilotica* remains the most frequently caught species, while *Salmoides* and *Vittatus* appears in lower quantities, supporting respondent perceptions of long-term ecological decline linked to weed proliferation and pollution. Environmental factors strongly influence fishing productivity, with respondents consistently highlighting pollution, invasive weeds, and fluctuating water levels as key drivers of reduced efficiency and habitat disruption. Governance structures at the dam are established but weakened by inadequate enforcement capacity, limited patrol resources, and growing poaching activities, despite high awareness of regulations among fishers. Finally, fishers face considerable socio-economic challenges—including theft of nets, poor infrastructure, limited markets, and competition—but demonstrate strong willingness to participate in community-driven co-management initiatives, signalling promising opportunities for governance reforms.

The study concludes that small-scale fisheries at Darwendale Dam operate within a complex ecological and socio-economic environment that simultaneously enables livelihoods and presents significant pressures on fish resources. The predominance of gillnet-based methods highlights adaptation to a multi-species fishery, while species distribution patterns indicate ecological shifts that require attention. Environmental degradation, particularly invasive weeds and pollution, is a major threat to fish populations, echoing regional trends across African inland fisheries. Although regulatory frameworks exist, they are hampered by inadequate enforcement, creating space for illegal activities that compromise sustainability. Socio-economic challenges further constrain fisher livelihoods, yet the strong demonstrated willingness among fishers to collaborate with authorities presents a critical opportunity for implementing participatory co-management. Sustainable fisheries at Darwendale Dam will depend on strengthening local governance capacity, improving ecological restoration efforts, and leveraging community participation to enhance resource stewardship. Collectively, the findings highlight the need for a more adaptive, inclusive, and ecosystem-based management approach to safeguard both the fishery and the livelihoods it supports.

5.3 Recommendations.

Based on the findings of this study, several recommendations are proposed in line with the study objectives. In relation to Objective 1.4.1, which sought to characterize the socio-economic and demographic attributes of small-scale fishers and establish the fishing methods used, there is a need to implement targeted capacity-building programmes

that promote sustainable fishing practices, improved gear selectivity, and livelihood diversification strategies to reduce overdependence on fishing. With respect to Objective 1.4.2, which focused on identifying fish species and monthly catch quantities, it is recommended that a routine catch monitoring system be established, whereby fishers and relevant authorities systematically record catch data to inform adaptive fisheries management, including effort regulation and potential restocking initiatives. In addressing Objective 1.4.3, which examined environmental factors influencing fish populations, the study recommends the implementation of environmental restoration measures such as the periodic removal of invasive aquatic weeds, monitoring and control of crayfish populations, and the establishment of a continuous water quality monitoring programme to track key ecological parameters and mitigate habitat degradation. In line with Objective 1.4.4, which investigated existing management frameworks and policies, strengthening institutional capacity through enhanced enforcement, provision of adequate resources to regulatory authorities, and the development of a formalized co-management framework involving fishers and other stakeholders is essential to improve compliance and governance. Finally, in response to Objective 1.4.5, which explored the challenges faced by small-scale fishers, the study recommends improving infrastructure through the development of accessible landing sites, upgrading of access roads, and installation of cold storage facilities, alongside promoting fishers' cooperatives and value-addition initiatives to enhance market access, stabilize incomes, and reduce post-harvest losses. Collectively, these recommendations support an integrated approach to fisheries management that balances ecological sustainability with socio-economic development at Darwendale Dam.

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APPENDICES

Appendix 1: The questionnaire used in the research

QUESTIONNAIRE FOR FISHERS AT DARWENDALE DAM

Introduction:

Thank you for participating in this survey, Esnath Chisero is a student from Bindura University of Science Education. The purpose of this questionnaire is to gather information on fish catches, environmental factors, fishing methods, and management practices around Darwendale Dam. This study is purely for academic purposes. Your responses will help in understanding the state of fishing operations and contribute to improving the sustainable use of the dam's resources.

Instructions:

Please tick (✓) the appropriate boxes or write your responses clearly in the spaces provided.

Section A: Respondent and operational context

1. How long have you been fishing?

a) Less than 1 year

☐

b) 1-5 years

☐

c) 6- 10 years

☐

d) More than 10 years

☐

2. Where do you reside?

.....

.....

.....

.....

.....

.....

3. Gender

Male

Female.....

4. What attracted you to the fishing industry?

☐

- a. Family business []
- b. Limited availability of jobs ☐
- c. Hobby [] ☐
- d. other

If _____ other,
specify: _____

5. Are you a registered fisher

- a. individual ☐
- b.cooperative ☐
- c. Unregistered ☐

Section B: Fishing methods and gear

1. What type of fishing gear do you use?

- a. Gillnets ☐
- b. Lines ☐
- c. Seine nets ☐

2. Please indicate the type gear and the type of fish caught

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

3. Do you own a boat or a fishing vessel.?

4. What is the average size and age of your fishing vessels?

.....

5. What is the average size of the nets or traps used?

.....

Section C: Catch and Species

1. Name the types of fish you catch?

- a.....
- b.....
- c.....
- d.....
- e.....
- f.....

2. Which are the most frequent species you catch?

.....

.....

.....

.....

3. how many kilograms of fish do you catch I average in each time(kg)?

specify

Daily

Monthly

Yearly

4. How often do you fish?

.....Daily



Weekly



.....Twice daily



5. When do you fish preferably?

Morning..... sunset

Other specify.....

6. Can you provide a breakdown of the catch by species and quantity species?

.....e,g Species A 20kg, Species B 10kg

.....

.....

7. How does your current catch compare to last year?

.....(more, less, the same)

8. a) Have you observed any change in the fish catch recently?

..... Yes no.....

b) If yes what are the changes increase in catch size or decrease in catch size

9. If yes indicate the probable causes of these changes

- a. pollution ☒
- b. changes in weather conditions ☒
- c. overfishing ☒
- d. improper techniques ☒

10. Are you able to estimate the abundance of small fish in your catch compared to last year?

11. Do you encounter any challenges?

.....Yes no

1. What are some of the challenges faced by fishers at Darwendale dam?

- a. Piracy ☐
- b. Poor infrastructure ☐
- c. Industrial activity ☐
- d. Pollution ☐
- e. Storage ☐
- f. Theft of engines ☐
- g. Small market ☐
- h. Competition ☐
- i. Overfishing ☐

Section D Environmental Factors Influencing Fish Populations

1. What environmental factors do you believe most affect fish populations in Darwendale Dam? (Select all that apply)

- Water temperature ☐
- Water clarity/quality ☐
- Water levels ☐

Pollution (chemical, waste, etc.) ☐

Seasonal changes (e.g., rains) ☐

Presence of invasive species ☐

Other (please specify)

.....

.....

2. Have you noticed any significant environmental changes around Darwendale Dam in the last few years?

Yes, water levels have changed significantly. ☐

Yes, water quality has worsened. ☐

Yes, there are more signs of pollution. ☐

Yes, the weather patterns have changed. ☐

No noticeable changes. ☐

Not sure ☐

3. How do these environmental factors (listed above) affect fish catches in the dam?

.....

.....

.....

4. Do you observe any specific areas of the dam where fish populations seem to be more abundant or scarce?

Abundant areas:

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Scarce areas:

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.....

Section E: Management Framework and Policies Governing Small-Scale Fishing

1. Are you aware of any local regulations or policies regarding fishing in Darwendale Dam?

Yes ☐

No ☐

Not sure ☐

2. What types of regulations or policies do you think are in place for small-scale fishers at Darwendale Dam?

Fishing seasons or closed periods ☐

Size limits for fish ☐

Restrictions on fishing gear ☐

Restricted fishing zones ☐

Permit requirements ☐

Other (please specify)

3. How well do you understand the regulations governing fishing in Darwendale Dam?

Very well ☐

Somewhat well ☐

Not well ☐

Not at all ☐

4. Have you ever encountered issues with the enforcement of fishing regulations in the area?

Yes ☐

No ☐

Not sure ☐

5. In your opinion, how effective are current management practices in ensuring sustainable fishing at Darwendale Dam?

a. Very effective ☐

b. Somewhat effective ☐

c. Not effective ☐

d. Not sure ☐

6. What suggestions do you have for improving the management of small-scale fishing operations at Darwendale Dam?

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7. Would you be willing to participate in community-driven management or conservation efforts around Darwendale Dam?

Yes ☐

No ☐

Maybe ☐

Thank you for your time and your valuable contribution. Your responses will help in understanding the current state of fishing practices and fish populations at Darwendale Dam.

Appendix 2 Interview Guide for Responsible Authority, Management, and Institutions

INTERVIEW GUIDE FOR RESPONSIBLE AUTHORITY, MANAGEMENT, AND INSTITUTIONS.

Introduction:

These questions are designed to collect information from authorities and management personnel involved in the governance and oversight of fishing activities at Darwendale Dam. This study is purely for academic purposes. Your responses will help assess trends, environmental influences, fishing practices, and policy effectiveness related to small-scale fisheries.

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Section A: Fish Catches and Species Composition

1. a. i) How many registered fishers operate at Darwendale Dam?
2. ii. Name the types of Fish found in Darwendale Dam?
3. How many kg of Fish do they catch daily or monthly?
4. Are there any programs in place to monitor biodiversity or fish populations at Darwendale Dam?

Section B: Fishing Methods Used by Small-Scale Fishers

1. What fishing methods are commonly used by small-scale fishers at Darwendale Dam?
2. Are there any regulations or restrictions on fishing gear or methods in the dam?
3. Does your organization provide training or outreach on sustainable fishing methods to small-scale fishers?
4. Have there been any observed changes in the fishing effort or practices of fishers in recent years?

Section C Environmental Factors Influencing Fish Populations

1. What environmental factors have had the greatest impact on fish populations at Darwendale Dam?
2. Is there a system in place to monitor water quality and environmental health of the dam?
3. Have you observed any significant environmental changes in or around the dam in the last 5 years?
4. What mitigation strategies are in place to address negative environmental impacts on fish populations?

Section D: Management Framework and Policy Implementation

1. Which policies or legal frameworks currently govern small-scale fishing at Darwendale Dam? (List known acts/regulations)
2. What institutions or bodies are involved in managing fishing activities at the dam?

(e.g., local government, fisheries department, co-operatives, community groups)

3. How would you rate the effectiveness of the current management system in regulating fishing at Darwendale Dam?
4. What are the major challenges in enforcing fishing regulations at the dam?
5. Are there any existing co-management or community-based management approaches in use?
6. Do fishers need licenses or permits to fish at Darwendale Dam?
7. Are there seasonal or spatial restrictions on fishing activities (e.g., closed seasons, protected areas)
8. What are your recommendations for improving the management of small-scale fishing at Darwendale Dam?

Closing Remarks:

Thank you for your contribution. Your responses will be vital in building a clearer understanding of the current situation at Darwendale Dam and in informing future management strategies.