AN ECONOMIC ASSESSMENT OF INLAND FISHERIES' CONTRIBUTION TO INCOME GENERATION AND FOOD SECURITY IN LIMPOPO PROVINCE, SOUTH AFRICA

by

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DECLARATION

I declare that the thesis hereby submitted to the University of Limpopo, for the degree of Doctor of Philosophy in Agriculture (Agricultural Economics) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and execution, and that all material contained therein has been duly acknowledged.

_____ _____

Surname, Initials (title) **Date**

DEDICATION

This thesis is dedicated to my family

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ABSTRACT

In South Africa, the presence of inland waterbodies provides opportunities for households to engage in fishing activities. The existence of fish and the availability of several waterbodies in the country's inland provinces provide households with alternative means of generating income and food security. With the prevalence of food insecurity, high unemployment, and poverty in the country, inland fisheries serve as an economic safety net, food, and source of income for rural poor households who live near impoundments. However, policymakers in South Africa have overlooked inland fisheries as a means of supporting rural livelihoods. Furthermore, the sector's economic and social contribution is frequently overlooked and underappreciated. Thus, inland fisheries are classified as informal due to the lack of legislation, despite the fact that rural households rely on this sector for income and food. Furthermore, the inland fisheries value chain is short, with little evidence of post-harvesting activities, and the roles and functions of rural households in this value chain are unknown. Despite this, inland fisheries provide a low-cost source of protein for households, and hence this sector has the potential to help reduce poverty, unemployment, and food insecurity.

Given this background information, the study aimed at assessing the contribution of inland fisheries to income generation and food security in the Limpopo Province of South Africa. The objectives of the study were to identify and describe the socio-economic characteristics of households and their different roles and functions played along the inland fisheries value chain in the Limpopo Province, to determine the contribution of inland fisheries to household income in the study area and to determine the contribution of inland fisheries to household food security in the study area. The study was conducted within three districts of the Limpopo Province namely, Sekhukhune District Municipality (SDM), Mopani District Municipality (MDM) and Vhembe District Municipality (VDM). Multistage and proportional sampling procedures were used to select 400 participants. In the study, both fishing and non-fishing households were interviewed. The motive behind interviewing non-fishing households is that they are mostly consumers of inland fish. Therefore, snowball and purposive sampling techniques were used to identify households who participate in inland fisheries. Snowball and the Convenient sampling technique were also used to identify the role players of inland fisheries. This was done to obtain information about the roles that households perform along the value chain of inland fisheries. Of the 400 households, about 193 are fishers who play either single or multiple roles within the value chain. A structured questionnaire was therefore used to collect data to achieve the objectives of the study.

The collected data was captured on Statistical Package for Social Science (SPSS) Version 27 for analysis. Several analytical tools from SPSS were employed to run the analysis. For instance, the descriptive statistics was used to identify and describe the socio-economic characteristics of households and their different roles and functions played along the inland fisheries value chain in the Limpopo Province. On the other hand, Pearson Chi-square and Pearson Correlation Moment were used to check the relationship between the socio-economic characteristics of households and their functions along the inland fisheries value chain. To determine the contribution of inland fisheries to household income, the study calculated the share of both fishing and non-fishing income activities to the total household income of households who only participate in inland fisheries. This was derived by using income share. To check the level of income diversification for fishing households, the study utilised the Simpson Income Diversity index (SID). The Multiple Linear Regression model was used to analyse factors that influence the income of fishing households. To determine the contribution of inland fisheries to household income, two food security measures were used. This includes Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Scale (HFIAS). Data were analysed for both fishing and non-fishing households to check the food security differences. Binary Logistic Regression model was employed to analyse the determinants of rural households' dietary diversity using HDDS which was grouped into Low dietary diversity and High dietary diversity. Furthermore, Multinomial Logistic Regression model was used to determine the effects of inland fisheries on household food security status.

Based on the findings, the study concludes that males dominate inland fisheries activities over females. Fishing is practised for food by both males and females, but there is also an aspect of income generation. Furthermore, most fishers prefer to capture fish at state dams, with Tilapia being the most common species in all the three investigated districts. However, Carp, Bass and Catfish are also amongst the preferred fish species. Additionally, households are likely to consume fish from inland waters at least once a week. The findings also show that selling raw fish contributes more to the overall household income in all the three districts. On average, households in SDM and VDM have a medium level of income diversity, whereas households in MDM have a low level of income diversity. Furthermore, the marital status of the household head, access to credit, and average quantity of fish are among the factors influencing the income of fishing households, whereas level of education, distance to fishing area, and number of years fishing are some of the determinants of dietary diversity. Similarly, gender of the household head, total household income, and type of agricultural activity are some of the significant variables that influence the food security

status households in the Limpopo Province. Additionally, the results show that there is a significant difference between the household food security of small-scale fishers, subsistence fishers, recreational fishers and non-fishing households. However, households in SDM and VDM are likely to be mildly food insecure where else households in MDM are likely to be severely food insecure. The study found that rural households in the study area play various roles within the inland fisheries value chain. These roles include input suppliers, fishers, traders, processors, and consumers. Additionally, there is exist a relationship between socio-economic characteristics of the households and their functions along the inland fisheries value chain. Lastly, the study concludes that the value chain of inland fisheries is short due to the lack of exports and formal markets in the study area.

To this end, the study recommends that policy makers should recognise inland fisheries as another way of sustaining rural livelihoods translating to income and food security. Moreover, awareness of the inclusion of inland fish in household food and the available opportunities for rural households in the value chain should be given attention by the government and relevant institutions. However, sustainable fishing practices is the central issue that should be prioritised by households under the guidance of the government to maintain a long and lasting livelihood.

Keywords: Inland Fisheries, Food Security, Income Generation, Rural Livelihoods

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AU	African Union
BASS	Bass Anglers Sportsman Society
BLM IDP	Ba-Phalaborwa Local Municipality Integrated Development Plan
CAADP	Comprehensive African Agricultural Development Programme
CPS	Cape Piscatorial Society
DAFF	Department of Agriculture, Forestry and Fisheries
DHA	Docosahexaenoic acid
DRDLR	Department of Rural Development and Land Reform
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EDD	Economic Development Department
EMLM IDP	Elias Motsoaledi Local Municipality Integrated Development Plan
EPA	Eicosapentaenoic acid
EPA-US	Environmental Protection Agency-United States
FANTA	Food and Nutrition Technical Assistance
FAO	Food Agriculture and Organisation
FASAF	Federation of South African Fly-Fishers
GCRF AFRICAP	Global Challenges Research Fund Agricultural and Food-System Resilience: Increasing Capacity and Advising Policy
GDP	Gross Domestic Product
GIS	Geographic Information System
GTLM	Greater Tzaneen Local Municipality
HDD	High Dietary Diversity
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HHI	Herfindahl-Hirschman Index
IDP	Integrated Development Plan
IFPRI	International Food Policy Research Institute
LDD	Low Dietary Diversity
LEDET	Department of Economic Development, Environment and Tourism
MDM IDP	Mopani District Municipality Integrated Development Plan

MDM	Mopani District Municipality
MLR	Multinomial Logistic Regression
MLRM	Multiple Linear Regression Model
MPA	Marine Protected Area
MSA	Municipalities of South Africa
NEPAD	New Partnership for Africa's Development
NPHAF	Not a Post-Harvesting Activity but Actual fishing
PAF	Partnership for African Fisheries
PUFA	Polysaturated fatty acids
r	Pearson's Product Moment Correlation
S.E	Standard Errors
SABAA	South African Bass Angling Association
SAGov	South African Government
SARS-Cov-2	Severe Acute Respiratory Syndrome Coronavirus 2
SASACC	Sport Anglers and Casting Confederation
SASCOC	South African Sports Confederation and Olympic Committee
SDG	Sustainable Development Goals
SDM IDP	Sekhukhune District Municipality Integrated Development Plan
SDM	Sekhukhune District Municipality
SID	Simpson Index of Diversification
SPSS	Statistical Package for Social Science
SSF	Small-scale fisheries
STATA	Statistical Software Analysis
Stats SA	Statistics South Africa
UNDP SA	United Nations Development Programme South Africa
USAID	United States Agency for International Development
VDM	Vhembe District Municipality
VIF	Variance Inflation Factor
WHO	World Health Organisation
WWF-UK	World-Wide Fund for Nature United Kingdom

CHAPTER ONE

INTRODUCTION

1.1. Background information

Fishing has remained a significant legacy of humankind for food and commercial purposes (Njagi *et al.,* 2013; Tursi *et al.,* 2015). To date, fisheries are still multidimensional as they contribute to the Gross Domestic Product (GDP), supply food, enhance government revenues, provide employment and boost exports (Yuerlita, 2013; de Graaf and Garibaldi, 2014; Shamsuzzaman *et al.,* 2017; Obiero *et al.,* 2019). In addition, fish is a predominant protein input relative to crops and animal sources (Sanchirico and Wilen, 2002).

Globally, fisheries constitute marine, inland fisheries and aquaculture. Both marine and inland fisheries consist of sub-sectors such as small-scale or subsistence, commercial and recreational (Funge-Smith and Bennett, 2019). Marine fisheries occur in the oceans while, inland fisheries are practised in natural community resources or common property waters such as freshwater, rivers, swamps, lakes reservoir and other man-made water bodies; and it is a labour-intensive activity involving capture, culture-based fishing and aquaculture (World Bank, 2012; Katiha *et al.,* 2014; Cooke *et al.,* 2016; Funge-Smith, 2018; Kumar *et al.,* 2019). Therefore, it is evident that inland fisheries do not take place in marine waters (Narayanan, 2016). Aquaculture on the other hand is fish farming that is practised in enclosed and secure spaces where production is monitored and controlled. Moreover, interventions regularly occur to increase the number of fish in a single unit (Troell *et al.,* 2017).

Over the years, much emphasis has been placed on the importance of marine and aquaculture to the global economy in terms of food, employment, income, traditional identity, and livelihoods (Cunningham, 2005; Ye and Cochrane, 2011; Pradeepkiran, 2019). Inland fisheries have been seen as contributing to people's livelihoods by providing food and employment all over the world. However, its importance has been overlooked, overshadowed, and unacknowledged (Britz *et al.,* 2015; Lynch *et al.,* 2016). Inland fisheries also face a number of challenges, including ill-advised development, poor labor practices and management, post-harvest losses, pollution, habitat loss, gender disparities, tenure and access rights, social welfare,

empowerment, environmental degradation, and climate change [Welcomme *et al.,* 2010; Bartley *et al.,* 2016; Stoop *et al.,* 2016; Ndhlovu *et al.,* 2017].

South Africa is known as an emerging middle-income country with a highly productive agricultural sector [Global Challenges Research Fund Agricultural and Food-System Resilience: Increasing Capacity and Advising Policy (GCRF AFRICAP), 2018]. Despite its ability to produce food, South Africa is food insecure at the household level [Statistics South Africa (Stats SA), 2019]. According to the South African General Household Survey, approximately 7.4 million people and 26% of households face poverty (Wilkinson, 2016). Children are frequently subjected to the consequences of poor diets, which can result in death or stunted development (Wenhold and Faber, 2008; Food Research and Action Centre, 2017). In the presence of inland fisheries, Welcomme *et al.,* (2010); Karataş and Karataş, (2017); Pradeepkiran (2019) confirm that fisheries contribute a significant amount of protein to human diets worldwide and can help poor households by generating income and food.

It is estimated that fisheries employ over 27000 South Africans (Brick and Hasson, 2016). Therefore, this sector can be a possible contributor to the growing economy of the country. There is however lack of reports and data on the production and harvest of fish, particularly within inland areas (World Bank, 2012; FAO, 2018a). Subsequently, the last report of inland capture fisheries in South Africa dates back to 1990 which does not indicate a true reflection of the current inland fisheries activities in the country (FAO, 2018a). This is because it is reported that there are inland fishing resources in the country that are being utilised for various motives such as small-scale fishing, subsistence fishing and recreational fishing (Britz *et al.,* 2015). However, this lack of report inhibits quantifying the economic contribution of inland fisheries to rural livelihoods. Moreover, the knowledge gap in inland fisheries stems from the lack of recognition of the sector as a source of improving rural livelihoods.

Previous studies have indicated that South Africa lacks an inland fisheries policy (Ellender *et al.,* 2010; Hara and Swarts, 2014; Kotzé, 2015; Britz *et al.,* 2015; Britz, 2015). However, in 2016, the government took to its initiative to draft a policy that aims to create an efficient regulatory regime for the inland fisheries sector to create an enabling environment to promote sustainable growth and transformation of the sector, to address the conflicts that arise between resource users and to recognize the

existence of inland fisheries as a source of livelihoods. The focus area for the implementation of inland fisheries policy in South Africa includes a legal and regulatory framework, access rights and authorisation, resource sustainability, maximising economic and social benefits, cooperative governance and co-management, research and monitoring, inland fisheries development support, transformation and broadening of participation, capacity building and monitoring and enforcement of authorisation conditions (South African Inland Fishery Policy Draft, 2019). Moreover, Britz *et al.,* (2015) suggest that the inland fisheries policy needs to be based on a value-added approach to increase the socio-economic benefits of inland fisheries. To this end, the inclusion of rural households in these value chain activities is likely to improve their livelihoods.

However, the lack of value addition facilities, storage facilities, market information, skills and knowledge in post-harvest management, poor and inefficient fish preservation techniques, and gender discrepancies, seems to be some of the challenges that fishers face in the value chain of inland fisheries (Phiri *et al.,* 2013; Odebiyi *et al.,* 2013; Edwards *et al.,* 2014; Manyungwa-Pasani *et al.,* 2017; Beran, 2018). These challenges tend to shorten the value chain of inland fisheries. Pedroza-Gutiérrez and López-Rocha (2016) convey that the flow of fish from fishers to final consumers is determined by the fish species, where the fish was caught, factors that define the production and distribution forces and mostly, the actors that are involved in this value chain. Moreover, the Sustainable Development Goals (SDG) seem to be more focused on the marine sector compared to the inland fisheries' sector (SDG 14) with none of the goals solely dedicated to inland fisheries [United Nations Development Programme South Africa (UNDP SA), 2020; Lynch *et al.,* 2020]. Therefore, it is against this background information that this study seeks to assess the economic contribution of inland fisheries to income generation and food security in Limpopo Province of South Africa.

1.2. . Problem statement

The global human population is expected to increase by 9.7 billion by 2050, and inland fisheries are currently regarded as one of the most important sectors in meeting the food supply challenges (FAO, 2016). In addition, fish is rich in nutrients such as

proteins, vitamins D and B2, calcium, phosphorus and minerals, which are important for developing good health (Belton and Thilsted 2014).

In South Africa, inland fisheries play an important role in impoverished communities due to their availability as a source of food, economic security, and income (Ellender *et al.,* 2009; Phosa and Lethoko, 2018). However, the inland fisheries sector in South Africa has been overlooked as a means of supporting rural livelihoods (Britz *et al.,* 2015). Unlike the marine sector, the economic and social contribution of inland fisheries is often undervalued and underappreciated (Tapela *et al.,* 2015). This could make most households vulnerable to food insecurity shocks, potentially affecting their ability to maintain their livelihoods.

The South African government, according to Sara *et al.,* (2017), has invested in impoundments to store water for agricultural, industrial, and domestic use. Although fishing is permitted within these impoundments, policymakers pay little attention to the households that live and fish near these impoundments. This could be because inland fishing is considered an informal activity (Britz *et al.,* 2015). Aside from this evidence, households are involved in various fishing activities such as catching and selling fish which makes them part of the value chain. Therefore, households share the benefits of the inland resources from the value chain (Alemu and Azadi, 2018). However, the value chain of inland fisheries in South Africa is short with little evidence of post-harvest value addition and the roles of households within this value chain are not clearly outlined (Britz *et al.,* 2015; Sara *et al.,* 2017). Considering these challenges, this study, focused on the economic assessment of inland fisheries' contribution to income generation and food security in Limpopo Province, South Africa.

1.3. Rationale of the study

The 2030 National Development Plan of South Africa seeks to eliminate poverty and encourage citizens to be active in their development. Inland fisheries have the potential to achieve these objectives through income generation and improving food security particularly among the rural poor [Department of Agriculture, Forestry and Fisheries, (DAFF) 2013]. In support of these, Sawada (2012) emphasised that income-generating activities such as those from fisheries could reduce rural poverty.

Inland fisheries in South Africa are mostly dominated by small-scale fishers and make less or no contribution to the economy of the country (Britz *et al.,* 2015). However, this

perspective does not overlook the nutritional and economic importance of this sector to rural livelihoods. This is because, the fish harvested serves as an important component of human nutrition by providing essential amino acids (Olatunji and Ogunremi, 2016). In addition, fish is an affordable source of animal protein in South Africa and functions as a source of income for most households (Ferreira, 2013; Tilami and Samples, 2017). Nonetheless, the importance of inland fisheries cannot be overstated. Lynch *et al.,* (2016) discovered, for example, that inland fisheries play an important role in individuals, society, and the environment by providing income, employment, and controlling disease-carrying pests such as mosquitos.

Despite its presence in South Africa, the economic contribution of inland fisheries to household income and food security, as well as the role it plays in rural livelihoods, is unknown. The reason could be that South African inland fisheries have not been recognized as a source of income (Britz *et al.,* 2015). Furthermore, an examination of the inland fisheries value chain may aid in identifying the various household actors and their roles along the value chain, which may aid in the creation of employment opportunities in rural areas. However, there is also little evidence of post-harvest value-adding. Such is the case in Limpopo Province. As the second poorest province in South Africa, Limpopo is a landlocked province and its occupants have no access to marine fishing (Mathebula *et al.,* 2016; Phosa and Lethoko, 2018). Rural households in the province often have difficulty meeting certain basic dietary needs. These require households to find some alternative sources of food, income and employment, hence fishing becomes to some extent, a solution for these rural households. Nevertheless, the province has access to inland water bodies from rivers and dams which produce fish such as Catfish, Tilapia and Carp (Tapela *et al.,* 2015). Resources from these inland water bodies could contribute to reducing poverty within households, thus there is a pressing need to investigate the economic assessment of inland fisheries' contribution to income generation and food security in Limpopo Province.

Few studies on inland fisheries have been undertaken in South Africa. For instance, Taylor, (2012); Jooste *et al.,* (2014) focused on the ecological and biological aspects of inland fisheries while Ellender *et al.,* (2014); Britz (2015); Marr *et al.,* (2017) looked at the conflicts arising from inland fisheries' resource users and access rights. Other studies viewed inland fisheries as a sport (Smit *et al.,* 2016; Barkhuizen *et al.,* 2017)

while McCaffety *et al.,* (2012); Hara and Backeberg (2014) paid attention to the use of inland water resources for fishing activities and its potential to produce fish for livelihoods. However, these studies did not account for the economic assessment of inland fisheries' contribution to income generation and food security. In addition, a common gap in these studies is that they did not examine the value chain of inland fisheries, its actors and their functions at the household level. On that premise, this study aimed to fill the research gap by assessing the economic contribution of inland fisheries to income generation and food security in Limpopo Province.

1.3.1. Aim of the study

The study aimed to assess the contribution of inland fisheries to income generation and food security in Limpopo Province, South Africa.

1.3.2. Objectives of the study were:

i. To identify and describe socio-economic characteristics of households and their different roles and functions played along the inland fisheries value chain in the Limpopo Province.
ii. To determine the contribution of inland fisheries to household income in the study area.
iii. To determine the contribution of inland fisheries to household food security in the study area.

1.3.3. Research hypotheses

i. Rural households only play the role of fishers and consumers in the value chain of inland fisheries.
ii. Inland fisheries do not significantly contribute to household income in Limpopo Province.
iii. Inland fisheries do not significantly contribute to household food security in Limpopo Province.

1.4. Organisational structure

The overall structure of the study takes the form of five chapters including this introductory chapter. Chapter two is a review of the literature which includes a definition of inland fisheries, recognition of inland fisheries from the international level,

an overview of inland fisheries in South Africa, socio-economic factors associated with inland fisheries, consumption, and contribution of fisheries to household income, food security. The role of women in fisheries and a concept note are also outlined in chapter two. Chapter three describes the study area which is the Limpopo Province and outlines the research procedures used in the study. Further, data collection methods and analytical techniques used in the study are discussed in chapter three.

The descriptive results, the relationship between role players and their function along the inland fisheries value chain, results for the contribution of inland fisheries to income generation and food security are presented in chapter four. Finally, chapter five draws upon the entire thesis where the summary, conclusion and policy recommendations of the study are discussed. Moreover, areas of further research are identified and discussed in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This chapter describes the literature reviewed in the study. Firstly, the definition of inland fisheries is discussed followed by recognition of inland fisheries from the international level, an overview of inland fisheries in South Africa, socio-economic factors associated with inland fisheries, contribution of fisheries to household income and food security. The different types of inland fisheries from the South African context are also elaborated. Moreover, the role of women in fisheries is also discussed in this chapter.

2.1. Defining inland fisheries

Fisheries is the science of producing fish and other aquatic organisms to provide food for humans through its resources. Although fisheries also serve as a sport (recreational fisheries), it is highly commercialised in developed countries, subsistence in developing and undeveloped countries while serving as income and nutrition generating activity for both poor and wealthy groups (Theng *et al.,* 2009; Martin *et al.,* 2013; McCauley *et al.,* 2018). Inland fisheries are defined as the harvesting of fish from the wild as compared to aquaculture (Simmance, 2017). On the other hand, inland fishers are characterised as the poorest and most vulnerable rural population, participate in fishing activities on a full-time, part-time or seasonally with most of the fish sold or consumed (World Bank, 2018; FAO, 2018a).

More emphasis on inland fisheries is placed on its scale. For example, Funge-Smith (2018), stress that inland fisheries are primarily rural and small-scale in nature with few activities of commercial large-scale fisheries. This definition qualifies inland fisheries as a sector dominated by rural households who participate on a small-scale and subsistence for food security and to generate wealth. Tapela *et al.,* (2015) emphasise that small-scale fishing on inland waters constitute various livelihood activities that households can partake in.

In the African continent, inland fisheries are artisanal and include activities such as catching, processing, transportation, trade and manufacturing of inputs [New

Partnership for Africa's Development (NEPAD), 2005]. Moreover, inland fisheries contribute to the reduction of poverty, food insecurity and, promotes income generation and employment (Simmance, 2017). Funge-Smith (2018) stress that resources from inland fisheries are mostly utilized by small-scale fisher folks. Studies have stressed the importance of fish as a major source of animal protein, polyunsaturated fatty acids, vitamins as well as minerals (Garcia and Rosenberg, 2010; Béné *et al.,* 2015; Pal *et al.,* 2018; Balami *et al.,* 2019; Obiero *et al.,* 2019).

2.2. Recognition of inland fisheries from international level

Globally, inland fish has been recognised as a contributor to food security, employment, economic development, and income generation (FAO, 2018a). In Africa, inland fisheries are known to play multiple roles in both the economy and on an individual/household level. For example, studies indicate that inland fish is a source of cheap protein, micro- and macro- nutrients and, is important for income generation for the majority of poor households (Béné and Neiland, 2003; Funge-Smith and Bennett, 2019). Therefore, this then puts the sector on a global and continental-scale as an improver of livelihoods.

Several structures have recognised inland fisheries in Africa. For example, the New Partnership for Africa's Development (NEPAD) which is a socio-economic flagship Programme of the African Union (AU) has four primary objectives which are to eradicate poverty, promote sustainable growth and development, integrate Africa into the world's economy and accelerate the empowerment of women. Inland fisheries fit in these objectives. Hence, the Partnership for African Fisheries (PAF) as a complementing programme of the Comprehensive African Agricultural Development Programme (CAADP), works to improve the sustainability of Africa's fisheries and improve the returns provided by this sector (NEPAD Flagship Programme, 2019). It aims to support an emerging political cadre or team that strengthens Africa's capacity to consider, determine and put in place-responsive reforms in fisheries governance and trade.

With these being the case, five key policy areas under PAF have been established to exchange ideas and provide solutions by working groups. These key areas include good governance, illegal fishing, trade and access to markets, aquaculture, and

finance and investment in fisheries and aquaculture (NEPAD Flagship Programme, 2019).

Additionally, Pan-African Fisheries and Aquaculture Policy Framework a reform strategy, seek to improve the reporting of fish harvested within the continent. This will help in estimating the contribution of African fisheries on a global scale (NEPAD Policy Brief fifteen, 2016). For instance, FAO (2018b) states that in countries such as South Africa, there has been poor reporting of fish harvested within the inland waters such as reservoirs. This then devalues the importance of fish in the continent as an important sector for rural livelihoods.

The demand for fish in the African continent is high, however, the supply is low given the growing population (NEPAD Policy Brief Six, 2016). This is as a result of overexploitation of both marine and inland fisheries resources due to; illegal fishing, unreported and unregulated fishing, pollution, deforestation, soil erosion, limited aquaculture production and high-post-harvest losses (Marshall, 2016; NEPAD Policy Brief Six, 2016; NEPAD Agency fisheries and aquaculture Programme, 2015-2020). Despite these encounters, inland fisheries provide essential nutrients for human development for both poor and rich households and serves as an economic safety net (Witt *et al.,* 2008; NEPAD Policy Brief Six, 2016).

2.3. Overview of inland fisheries' sector in South Africa

The South African fisheries sector is dualistic comprising of marine fisheries and inland fisheries. These sectors contribute towards income, food security, employment, poverty reduction and tourism (FAO, 2018a). However, inland fisheries in South Africa are dominated by recreational and small-scale fisheries. Also, it is stated that commercial inland fisheries that are equal to marine fisheries in South Africa do not exist due to the low production of fish within the inland water bodies (McCaffety *et al.,* 2012; FAO, 2018b). Nevertheless, economically desirable fish species such as Mozambique Tilapia (*Oreochromis mossambicus), common carp (Cyprinus carpio)* and common barbel/catfish *(Clarias gariepinus), redbreast tilapia (Coptodon rendalli)* which are found in most impoundments like in the Limpopo Province, can serve as an affordable protein source and serve as a safety-net for the majority of households living close to the impoundments (Nibamureke *et al.,* 2016; Sara *et al.,* 2017).

Moreover, the population within the South African landlock provinces eat less fish as compared to coastal residents (FAO, 2018b). This might be a result of poor participation of households in inland fisheries due to the marginalisation of the sector. In addition, South Africa is a water-scarce country, but the freshwater ecosystems are diverse and range from sub-tropical in the north-eastern part of the country to semi-arid and arid in the interior, to cool and temperate rivers of the fynbos (Skowno *et al.,* 2019). Freshwater ecosystem refers to water bodies whether fresh or saline which includes rivers, lakes, wetlands, sub-surface waters and estuaries (Nel *et al.,* 2011).

A previous report by Neil *et al.,* (2011) states that freshwater fauna which is indigenous to South African waters, has displayed an increased level of threat due to pollution, overfishing and competition. As a result, aquaculture is classified as a sector that can reduce this problem (Halley and Semoil, 2021). Although aquaculture is growing in South Africa, it is however limited to the supply of suitable water for production, land and it is an expensive fish production (Amenyogbe *et al.,* 2018; FAO, 2018b). On the other hand, resources from inland fisheries are accessible to the rural poor, because the use of public dams creates an opportunity for the development of inland fisheries especially on a small-scale level to contribute significantly towards food security and rural livelihoods of fishing communities (Isaacs and Hara, 2015).

As the custodian of water resources in South Africa, the Department of Water Affairs and Sanitation (DWS) is responsible for controlling the activities that take place in the dams (South African inland Policy draft, 2019).Thus, most inland fishing activities take place in state, private dams, and rivers (Erasmus *et al.,* 2019). With most of the angling taking place at state-owned dams (about 69% of dams), there are various reports of conflict between the resource users (particularly recreational anglers and small-scale fishers) [McCaffety *et al.,* 2012; Ellender *et al.,* 2014; Britz *et al.,* 2015; Britz, 2015; Marr *et al.,* 2017]. These conflicts arise from a lack of accoutrement of the customary common pool rights, lack of capacity of communities to participate in inland government structures, ecological effects of legal and illegal gill net fishing hence access by small-scale fishers is marginalised on the majority of the water resources. Moreover, the exploitation of inland fish on inland waters and impoundments is extensive in South Africa (FAO, 2018b). This might be a result of the accessibility of inland fish resources that is available to people (often landless poor people in remote

areas), it is open-access and available in rural and developing areas where inexpensive, little or no mechanization is used (Funge-Smith and Bennett, 2019).

On the other hand, the Department of Environmental Affairs together with the Provincial Departments of Environmental Affairs oversee managing the environment and conservation of inland fish population under the National Environmental Management Act and the Environmental Acts and Ordinances within the various provinces. Hence the majority of dams in South Africa are managed by the Department of Water and Sanitation and access to fish at these dams require permits. Although the majority of the households fishing around these dams have no permits hence their fishing activity is deemed illegal, the South Africa is in the process of developing a National Freshwater (Inland) Wild Capture Fisheries Policy which will view inland fishing as legal (Weyl *et al.,* 2020).

2.4. Classification of inland fisheries in South Africa

Inland fisheries in South Africa can be classified into three sub-sectors which are: small-scale fisheries (SSF), recreational fisheries and commercial fisheries. The discussions of each of the sub-sectors are then discussed below.

2.4.1. Small-scale fisheries (SSF)

Small-scale fisheries are defined as traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore and mainly for local consumption (FAO, 2015; Farrugio, 2013; Halim *et al.,* 2019). On the other hand, small-scale fishers are defined as persons that fish or are engaged in small-scale fishing activities to meet food and basic livelihood needs. They predominantly employ traditional low technology or few fishing gear, usually undertake single day fishing trips, and are engaged in sale or barter or are involved in commercial activity. To this end, this study defines small-scale fisheries as an activity involving households who fish using traditional or inexpensive vessels and are involved in both sale and consumption of the fish caught.

According to Smith and Basurto (2019), SSF is found in inland waterways and seas across the world. In addition, small-scale fishers use small or no fishing vessels and

relatively low technology fishing methods. Moreover, this subsector tends to be labour intensive, often seen as an activity of low productivity with low yields and low-value products which are mostly for local consumption (World Bank, 2012). Regardless of whether small-scale fishers operate full-time or part-time, inland fisheries still provide a source of food and income to many households (World Bank, 2012).

2.4.2. Recreational fisheries

Recreational fishing is defined by FAO (2012) as fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or other markets. Recreational fishers on the other hand are those who do not rely on fishing to supply a necessary part of their income (FAO, 2012).

According to McCaffety *et al.,* (2012), recreational fishing within the South African inlands dates back to the 19th Century where different fish species such as *Cyprinus carpio*, *Salmo trutta*, *Oncorhynchus mykiss*, *Micropterus salmoides*, *Micropterus dolomieu*, *Micropterus punctulatus* and *Micropterus floridanus* were introduced for angling purposes. The recognition of inland fisheries for commercial, rural development and food security was realised in the 1960s. Britz *et al.,* (2015) point out that, the South African recreational sector has an estimated 1,2 million participants, and this sector significantly contributes to tourism. Moreover, this sector includes bank angling for fish types such as carp, yellow fish, and catfish. Artificial lure angling is for bass fish and other fish species. Flyfishing for trout, boat angling and informal recreational/subsistence angling are also some of the activities practised by anglers in this sector (Britz *et al.,* 2015). Members of the angling groups are affiliated with the South African Sports Confederation and Olympic Committee (SASCOC) under the Sport Anglers and Casting Confederation (SASACC).

The majority of the recreational activities take place at the state-owned dams, thus, the Department of Water Affairs (DWA) supports these activities. Britz *et al.,* (2015) further outline that recreational fisheries are not recognised as a contributor to rural livelihoods, however, this sub-sector contributes to the tourism and angling supply value chain.

Recreational fishing as a sport includes specialisation in the fishing of non-native fish species which has its association [South African Bass Angling Association (SABAA)]. Teams from across the African continent such as those from South Africa, Swaziland, Mozambique, Namibia and Zimbabwe are affiliated to the Bass Anglers Sportsman Society (BASS) which is located in the United States of America. This suggests that recreational fisheries are not only a sport but also contribute to tourism (Ellender *et al.,* 2014). The targeted fish includes *Cyprinus carpio* (for members of African Freshwater Bank Angling Federation), *Oncorhynchus mykiss* and *Salmo trutta* [for members fly fishing organisations such as Cape Piscatorial Society (CPS) and Federation of South African Fly-Fishers (FASAF)] (Ellender *et al.,* 2014). Moreover, recreational fishing has a significant economic impact associated with the angling activities and supply value chains (Britz *et al.,* 2015).

2.4.3. Commercial inland fisheries

According to McCaffety *et al.,* (2012), commercial fisheries is the type of fisheries that is operated by a private individual who is granted access at the provincial level to harvest a pre-determined yield from a dam. The main goal of engaging in commercial fisheries is mainly for profit generation. However, there has been an attempt to develop the sector in the 1960s and 1970s but, challenges such as conflicts among waterbody users, poor gears, lack of access rights, historical discriminations, overexploitation of inland resources and lack of policy posed as limitations for the development of the sector commercially (McCaffety *et al.,* 2012; Britz *et al.,* 2015).

In a country such as South Africa, commercial inland fisheries that are like marine fisheries does not exist (McCaffety *et al.,* 2012). The contributing factors to the nonexistence of commercial inland fisheries in South Africa are highlighted by several authors. These include low production of fish, lack of information, low yield and prices for freshwater fish, illegal fishing, poor access to market for inland fish and poor access rights (McCaffety *et al.,* 2012; Britz *et al.,* 2015; Barkhuizen *et al.,* 2016).

Commercial inland fishing is only permitted in the form of a single license at few dams such as Gariep, Bloemhof and Moletedi dam (Weyl *et al.,* 2007). There is only one reported commercial inland fisher in the Free State Province mainly operating at Bloemhoof Dam (Brtiz *et al.,* 2015). This, therefore, proves that there is potential for

commercialisation of inland fisheries. The lack of legislation of the sector also plays a negative role in establishing commercial inland fisheries in South African impoundments (Britz *et al.,* 2015; Tapela *et al.,* 2015).

2.5. Potential of inland fisheries in South Africa

South Africa is rich with perennial and non-perennial rivers, and several reservoirs that have a potential for inland fisheries. For example, Britz *et al.,* (2015) state that there are 4703 dams in South Africa. Therefore, the production potential of inland fisheries was estimated in some of the major dams using the Geographic Information System (GIS) model (Britz *et al.,* 2015). The GIS was used to identify regions that had high potential for inland fisheries and 425 dams were evaluated. It was found that fish such as Bass, Carp, Catfish, Cyprids, Tilapia and Trout were found to exist in these dams with most fishing potential occurring in warmer areas such as Limpopo, Mpumalanga and KwaZulu-Natal (Britz *et al.,* 2015). Moreover, the evaluated dams showed that small-scale and recreational fisheries exist in these dams. For example, in Tzaneen Dam, it was found that recreational and small-scale fishing occur and there is the potential for small-scale commercial fisheries that would yield about 140 tons per year.

Inland fisheries in South Africa was established by stocking alien fish species for angling purposes by the British colonists (Britz *et al.,* 2015). Previous research shows that South African inland fisheries have the potential to produce 15000 tonnes of fish (McCaffety *et al.,* 2012). Currently, the potential of fisheries in dams such as Flag-Boshielo Dam was estimated to determine fish species using gill nets. It was found that fish species such as *Labeo rosae*, *Oreochromis mossambicus*, *Schilbe intermedius* and *Labeobarbus marequensis* contributed 40%, 15%, 10% and 9.8% of biomass respectively (Sara *et al.,* 2017). Similarly, Sara *et al.,* (2021) found a total biomass of 247.6kg of *Labeo rosae* and *Oreochromis mossambicus* in the Flag-Boshielo dam. To sustain the *Oreochromis mossambicus* and red nose labeo in the Flag-Boshielo dam, Sara *et al.,* (2021) recommend placing restrictions on gillnets with a mesh size of 100mm. This is because both fish species are dominant in the dam and preferred by both subsistence and recreational fishers. Therefore, proper fish management and regulation are needed to sustain the fish for food security and income generation.

Several studies have also identified different fish species within the inland waters such as dams and rivers in South Africa. For example, Ellender *et al.,* (2010) found species such as *Labeo capensis, Labeo umbratus, Labeobarbus aeneus, Labeobarbus kimberleyensis, Cyprinus carpio, Clarias gariepinus, Barbus anoplus* and alien salmonids and centrarchids in Gariep Dam in the Free State Province. Sara *et al.,* (2017); Sara *et al.,* (2021) found *Labeo rosae*, *Oreochromis mossambicus*, *Schilbe intermedius* and *Labeobarbus marequensis* in Flag-Boshielo Dam in the Limpopo Province. *Labeobarbus aeneus, Labeobarbus kimberleyensis* and *Labeo umbratus* were found in Vaal dam which borders Gauteng and Free State Provinces. Fish species such as *Tilapia rendalli*, *Oreochromis mossambicus*, *Clarias gariepinus* and *Synodontis zambezensis* were caught by rural households in the lower Phongolo River flood plain in northern Kwazulu Natal (Coetzee *et al.,* 2015). These studies provide evidence of fish availability within South African inland waters

Previous research such as that conducted by Ellender *et al.,* (2010) has estimated that about 46.9t/year of fish from Lake Gariep dam was either consumed or donated for research. From these results, about 18t/year was sold and 6.2t/year released back to the inland waters (by recreational anglers). These results indicate the potential of fish within the inland waters.

Although, rural communities mostly fish for consumption, these communities also practice recreational fishing, however, fish caught is consumed (Britz *et al.,* 2015). Despite this information, there exist conflicts among the users of inland fisheries on certain dams due to lack of recognition for customary common pool rights and poor participation of rural communities in existing governance particularly small-scale and recreational fisheries [Ellender *et al.,* (2014); Britz (2015); Marr *et al.,* (2017)]. This is also due to the lack of policy within the inland fisheries in South Africa unlike the marine sector (Kotzé, 2015). Conversely, the use of inland fisheries by the community showed unrestricted legacies of disposition and marginalisation from customary resource access which arise from Apartheid and Colonial-era dam building, forced removals and land disposition. However, small-scale fisheries were tolerated by authorities, persisted to be vulnerable to prosecution and their activities were mostly marginalised by other resource users and stakeholders (Britz *et al.,* 2015). Despite these challenges, small-scale inland fishing occurs on 77% of the dams. Moreover, recreational fishing was estimated at 69%, while small-scale commercial fishing was

40% (Britz *et al.,* 2015). Though fish is available all year round, the probability of an angler (fishers) for both recreational and subsistence having caught a fish in winter is low compared to summer (Ellender *et al.,* 2010). Likewise, the availability of fish provides an opportunity for rural poor households to obtain a cheap source of protein (Balami *et al.,* 2019). To this end, fish within the inland waters is available however, there is a need for formal regulation and management so to sustain the sector for, food security, tourism and income generation.

2.6. Socio-economic factors associated with inland fisheries

Socio-economic factors are important in understanding the behaviour and the decision making of households. Similarly, a wide range of studies associated with socio-economic factors of households in fisheries has been explored. For example, Al-Asif and Habid (2017) conducted a in Jhikargachha upazila, Jessore district, Bangladesh. The study shows that the majority of the fishers are between the ages of 50-60 years. Suggesting that although the fish farmers are still in their active stage, most of them are nearing retirement. The shortfall of this study is that the relationship between the socio-economic conditions and the livelihood status of the fish farmers could have been analysing to understand the relationship between these variables.

A study by Endalew *et al.,* (2020), found that socio-economic factors such as the age of the household head, education status, household size, extension service and access to modern transportation are factors that affect household participation in fish production. Age is an important factor that determines the active stage and economic ability of the respondent. For example, in a study conducted in India by Katiha *et al.,* (2014), it was found that 46.48% of the fisher folks were between the ages of 36-55. In Bangladesh, only 39% of the fisherfolks between the ages of 31-40 years were involved in fishing activities (Sunny *et al.,* 2019). This suggests that fishing is not for all age groups and those who are involved in fishing activities are still in their active stages. Moreover, age indicates the fishers' ability to handle some of the activities that are associated with inland fisheries and the adoption of new technology. Furthermore, age is related to experience, skills and informed decision making because, the older the farmer, the more experience they have in a particular enterprise.

In a study by Pandit *et al.,* (2019), it was revealed that about 40.4% of the respondents are illiterate. Only 12.4% can read and write and, the average years spent in school was found to be two years. The assumption here is that education is not considered an important aspect of human development in the study area. This might be attributed to various factors such as the poverty state of the households and unfair education opportunities. The importance of literacy is that educated individuals mostly make informed decisions and are likely to recognise the importance of new technology adoption and, opportunities to sell their catch at formal markets. Moreover, the average age was found to be 46 years suggesting that most of the respondents are in their active stage. Hence, the income from the fisheries can also be used to develop the descendants of the fishers through education. It can then be said that the age of the respondent influences their skills/experience of fishing, therefore such should be passed to younger age so that there will be continues maintenance of livelihoods.

A study by Endalew *et al.,* (2020) analysed the determinants of farm households' participation in fish production in Southwest Ethiopia. The study divided 120 respondents into those participating in fisheries (60) and the non-participants (60). The results revealed that, 43.3% and 7.5% of the respondents who participated in fishing were literate and illiterate respectively. Consequently, the education status of the non-participants revealed that about 25% and 24.2% are literate and illiterate respectively. To this end, it can be noted that education needs to be emphasised by the government to develop the learning capacity of the households. Therefore, these factors are essential in the design of policies that promotes participation in fishing as a source of food security, poverty reduction and employment. On the other hand, Fazilah *et al.,* (2012) emphasise that being educated gives an individual value and respect in the community and serves as a prerequisite for improving self-confidence, reducing poverty, improving the standard of living and building a food secured world. While a study conducted by Katiha *et al.,* (2014), found the average fishing household size in India to be 4.68 which is associated with the availability of labour.

A considerable amount of literature has outlined that fishing is mostly dominated by males. For example, Katiha *et al.,* (2014) indicated that the participation of males in inland fishing in India outnumbered females. Other studies have indicated that females are mostly involved in all value chain activities of fisheries while other studies argue

that females are mostly involved in the pre- and post-harvesting activities (Brugere and Williams, 2017; Raemaekers and Sunde, 2015; Limuwa, 2019). Surveys such as those conducted by Alemu and Azadi (2018) show that households headed by males are likely to participate in fisheries as compared to females. This might be attributed to the fact that actual fishing is labour intensive, females have multiple roles to play within the household and in the community other than fishing. Ownership of resources such as land, and the safety concern of female's participation in fisheries especially where it involves fishing at night and during high tides, seem to limit female participation in fishing (Alemu and Azadi, 2018). Additionally, Maina *et al.,* (2014) found that in Kenya, males dominate fishing and participated in government programs such as Fish Farming Enterprise and Productivity Program since they meet the requirement of land ownership compared to females. This, therefore, exposes gender disparities within the fisheries sector and the unfair allocation of resources.

Institutional factors such as access to extension services and access to credit were also perceived as important in fisheries by Endalew *et al.,* (2020). It is worth noting that access to extension services facilitate access to information. However, not all fishing households have access to this service. To this end, demographic and institutional factors of households play important role in fisheries.

2.7. Contribution of inland fisheries to income generation

As a subsector of agriculture, the contribution of fisheries to household income has been studied across the globe. For example, a study conducted by Sonjiwe *et al.,* (2015) focused on the contribution of artisanal fisheries towards livelihoods and food security among communities of Chanyanya Fishing Camp in Kafue District of Lusaka Province. The study involved the collecting of both primary and secondary data and only focused on artisanal fisheries and the non-participants. It was observed that all the respondents are males. This confirms that fisheries are a male-dominated sector. However, the study outlined that females were more comfortable in fish trading and marketing. It was revealed that participation depends on how far the households live to the river to facilitate easy accessibility to this fishing resource. The income raised from the sales of fish was used mainly for household expenses, food and buying fishing equipment. Hence, it was revealed that 40% of the respondents' viewed

fisheries as a profitable activity, with 94% indicating that fisheries are the primary source of income.

Khatun *et al.,* (2013) also found that fishing improved the livelihoods of fishers in Charbata, Noakhali, Bangladesh with 94% reporting a positive contribution of fish production to their livelihood. Katiha *et al.,* (2014) also established that fishing is a source of income for the majority of households in India, followed by business, agriculture and labour services. A higher income generating source comes from fisheries. It appears that the source of income is a vital indicator of the socio-economic status of the households.

Parashar *et al.,* (2016) conducted an assessment of the socioeconomic status of fishermen communities selected from the River Narmada, India. The study found that fishing is the major source of income for traditional fishing households, however, these households were occasionally involved in non-fishing activities such as fruit and vegetable production. This suggests that fishing is closely interlinked with the livelihood strategies of agriculture. Other households had other sources of income such as government employment and wages. However, the study also found that fishery-related activities such as fish marketing, trading, gear and craft maintenance and repair contribute less to household income. Nevertheless, Parashar *et al.,* (2016) study did not quantify to which extend do these activities contribute to household income. On the other hand, it was also observed that males dominate fisheries in the study area while females are involved in the fisheries' value chain having functions of preparing and repairing fish nets and, participation in the supply chain of the fish market.

An earlier study which was conducted by Rahman *et al.,* (2011) found that fishers in Mymensingh District diversify their income with activities such as crop production, livestock farming, wage-earning services, business and remittance. However, income from fishing activities made a more significant contribution than non-fishing activities. According to Hanh and Boonstra (2019), having alternative sources of income is well-thought as an effective way to limit the exploitation of natural resources and also a way of improving the welfare of the local resource users.

Zella and Mpemba (2017) assessed the determinants influencing fishing income to the coastal households of Indian Ocean. The study used both primary and secondary data. For primary data, the Participatory Rural Appraisal (PRA) was used to randomly select 120 households. Principal Component Factor analysis was employed to identify the most suitable factors that determine fishing income. Furthermore, multiple linear regression was used to analyse the determinants of fishing income in the study area. The study found that fishing is the main economic activity in the study area, however, households also diversified their income to boost the income received from fisheries. Therefore, this suggests that diversifying household sources of income improves the livelihood of households. Moreover, the regression results revealed that level of education and financial support negatively influence fishing income whist, fishing gear and the number of labours had a positive relationship with the household fishing income. It can then be argued that the level of education and financial support or access to credit is likely to boost the income of fishing households.

Batoa *et al.,* (2016) used income and contribution analysis to analyse the fishermen's wife's income and the contribution of that income to the total household income. The study found that wives perform other economic activities to increase household income while their spouses are mainly involved in fish harvesting. It was found that the housewives performed economic activities such as selling fish, coral-reef seaweed, firewood and cookies. This indicates that women, particularly housewives, contribute to the diversification of income sources of the households. However, the study, therefore, leaves a gap on the factors that influence the diversification of income sources by households to understand the relationship between these factors and the participation of wives in economic activities. Although the wives contribute to the household income, it was concluded that the contribution is low.

Elsewhere in Bangladesh, it was found that fishery training programs had created a substantial impact on the households' income of rural poor women while the number of fishery training received, total land possesses by the households, amount of fishery credit received, number of natural hazards faced by the household are the determinants of household income (Mahmud *et al.,* 2017). Paulus *et al.,* (2019) corroborate that the economy of the households increases when it is supported by the wife's income. The results by Mulokozi *et al.,* (2020) validates that fishing contributes

to the total household income however, some challenges are responsible for the low participation of households in this sector. Thus, the income from non-fishing activities serves as an important backup source of income for households participating in the sector.

Similar studies were also conducted in relation to fisheries and income. For example, Martin *et al.,* (2013) investigated the relationship between fishing, livelihood diversification and poverty in the lower Mekon basin in Laos, Savannakhet Province. The study concluded that fishing contributes as a source of income, employment and food security, particularly for poor rural households. The study outlined that, activities from inland fisheries contribute the largest share to rural livelihoods, however, to some households, it is a secondary source of income. Zella and Mpemba (2017) found contradicting results as it was highlighted that fisheries serve as the primary source of income and it contributes a larger share to the household income.

In another study, it was found that a greater portion of fishing households contribute more to the total household income (Mfinanga, 2014). Additionally, alternative fishing activities, access to credit, land size, organisation participation and education negatively influence a household's decision to be involved in fishing while household size had a positive influence. Perceived influential factors were family business, available fish market, short time of earning income, small initial capital and free access to water bodies. It is therefore important to integrate these factors to better understand the underlying reasons that push or prevents fishing households from participating in fisheries as a source of livelihood.

In studies conducted by Martin *et al.,* (2013), it was observed that fishing is an income-generating activity for poor households due to the open-access to the water resources. Studies such as Branch *et al.,* (2002) argued that small-scale inland fishing does not require large capital as compared to agriculture which requires access to land. This is because there are other open-access resources that households can utilise to obtain fish. However, other studies have found that changes in the climate affect fishers' economic status (Paulus *et al.,* 2019). This might be that fishing is a risky sector due to its climate sensitivity which in turn affects fish breeding, health, growth and reproduction in both marine and inland fisheries (Sharma *et al.,* 2015; Muringai *et al.,*

2020). It can therefore be said that having different income sources will serve as a rescue strategy for fishing households.

2.8. Contribution of inland fisheries to household food security

The 1992 United States Agency for International Development (USAID) defines food security as a condition where all people always have both physical and economic access to enough food to meet their dietary needs for a productive and healthy life. Additionally, a household is said to be food secured when all members of the household residing together, can physically, socially and economically secure sufficient, safe and nutritional food at all times to meet their dietary needs to live an active and healthy lifestyle (FAO, 2006).

Globally, less than 10% of people live below the poverty line and survive on $1.90 per day, and as part of the Sustainable Development Goals, world leaders have aimed to eradicate extreme poverty of everyone by 2030 (World Vision, 2018). Inland fisheries including aquaculture, in this case, have been recognised to meet the growing food demand, thus forming part as a solution to poverty (FAO, 2016). Consequently, maintaining inland fisheries can support the sustainability of food security across the globe thus reducing the prevalence of food insecurity within the households.

Other studies have recognised the positive effect of incorporating rice farming with wild aquatic species production for food and nutrition security (Freed *et al.,* 2020). On the other hand, the South African government has recognised that inland fisheries are another way of conserving marine fisheries due to the challenges of overexploitation (DAFF, 2014). From a well-being perspective, consumption of inland fish is related to the high quality of easily digestible proteins, additionally, fish contains micronutrients which are key to reducing micronutrient deficiency diseases (Mohanty *et al.,* 2019).

Research on the South African inland fisheries indicates that fish plays a vital role in food security and nutrition (Britz *et al.,* 2015). Still, the consumption of fish is associated with good development of the brain, well growth, good immunity and is crucial for the nervous system (Towers, 2015). Additionally, the general consumption of fish is predominantly important for women and children due to their high demand for micronutrients and protein (Bennett *et al.,* 2018). With these being said, inland fisheries are important for global and household food security.

2.8.1. Contribution of inland fish to dietary diversity and quality

Malnutrition and poor diets are viewed as the leading causes of diseases all over the world [International Food Policy Research Institute (IFPRI), 2016]. Also, underprivileged households generally have limited income to purchase food for consumption (French *et al.,* 2019). Therefore, the lack of economic resources, lack of infrastructure, unstable markets, climate change, socioeconomic inequality leads to households being vulnerable to poverty and malnutrition (Mutisya *et al.,* 2015; Grobler, 2016; Stats SA, 2019; Lukwa *et al.,* 2020). These households, therefore, have a habit of prioritising food items, thus compromising dietary diversity. In developing countries, fisheries can address the problem of malnutrition among households (Vianna *et al.,* 2020). For example, common inland fish species such as Tilapia, Carp, Bass, Catfish, Troat and Tigerfish serve the purpose of providing essential nutrients to communities and are be prepared in different ways (Balami *et al.,* 2019). Therefore, fisheries generally serve as a source of food security and household nutrition for vulnerable households (FAO, 2020). Moreover, fish is healthy and safe to be consumed as a whole due to its considerable high ratio of protein/fats compared to meat from goat, lamb, buffalo and chicken (Lilly *et al.,* 2017).

A recent study by Heilpern *et al.,* (2021) established that substituting wild inland fisheries with aquaculture and chicken increases iron deficiencies and limit essential fatty acids. The study also emphasises that the production of chicken and aquaculture increases greenhouse gas emissions, agricultural land use and aggressively increases the growth of plant and algae within water bodies. Additionally, other animal protein and nutrients sources are expensive for the rural poor or not easily available (Belton and Thilsted 2014). To this end, inland fisheries is a good source of animal protein for all people.

Funge-Smith and Bennette, (2019) emphasise that the dietary diversity of humans may be greater if wild foods are consumed. Therefore, fish from the wild consume a natural diet, contain few antibiotics, fresher and healthier as compared to farmed fish (Claret *et al.,* 2014). This, therefore, suggests the importance of fish from the natural ecosystems for dietary and nutritional security. For instance, fish species such as Tilapia are rich in omega-3 fatty acids, vitamin D, B12 and B6. Hence, it is argued that fish from freshwater is preferred compared to aquaculture due to its inexpensiveness

(Amenyogbe *et al.,* 2018; Towers, 2015). This might be that most fishing resources are open to the public and free to access. Keeping this in the backdrop, the consumption and utilisation of fish tend to differ from one consumer to another due to environmental, geographical area and adaptability of fish to different climatic conditions (Can, 2015; Towers, 2015; FAO, 2016). For example, common fish species such as Tilapia, Carp and Catfish are said to adapt well to different feeding habits, are acceptable by consumers, are resistant to diseases and are common in various water bodies (Davis *et al.,* 2009; Towers, 2015). Additionally, fish is available and affordable to different income groups compared to red meat (Mohanty *et al.,* 2019; Onumah *et al.,* 2020).

Given that higher dietary diversity is associated with growth in children, O'Meara *et al.,* (2021) examined the diets of children aged 6 to 23 months in sub-Saharan Africa. The study found that many of the children had inadequate dietary diversity. However, fish was the most consumed animal source of food with 20% of children within rural areas relying on fish for higher dietary diversity scores. In a study by Bogard *et al.,* (2017) it was found that non-farmed fish contributes to the nutritional diet of children in Bangladesh and these fish species have more micronutrients compared to fish from aquaculture. Evidence from other studies reveals that the consumption of fish is associated with the prevention of high blood pressure, diabetes, cholesterol, cardiovascular diseases, depression, attention deficit hyperactivity, cancer, and helps with the promotion of brain development [Bedada and Lemma, 2017; South African Government (SAGov), 2018; Mohanty *et al.,* 2019].

Although large and small inland fish species dominate the sector, both contribute to the dietary and nutritional security of households. For example, Belton and Thilsted (2014) suggest that small fish species from capture fisheries are higher in nutrition compared to aquaculture fisheries. However, the nutritional composition of fish differs according to the fish species, the way the fish is processed and how they are marketed (FAO, 2020). This is because different fish species are preferred and prepared in different ways. For example, fish can be grilled, baked or fried (Can *et al.,* 2015). Therefore, the consumption of fish is associated with good nutrition which is the basis of good health.

So far, fish contains macronutrients (such as protein, lipids, ash), micronutrients (such as vitamin A, B12, D, E, and Folate), minerals (such as iron, zinc, calcium, iodine, selenium, phosphorus and potassium which are essential for good human development (Bogard *et al.,* 2015; Gurung, 2016; Vilain and Baran, 2016; Jim *et al.,* 2017; SAGov, 2018; Mohanty *et al.,* 2019; Balami *et al.,* 2019). Vitamin D is important in assisting the body to absorb calcium which together, helps protect the body from developing diseases such as osteoporosis which thins and weakens bones (National institute of health, 2021). Fish species such as Carp are high in iron (Vilain and Baran, 2016). Vitamin A, Zinc is high in small fishes that can be eaten whole (Kawarazuka, 2010). Therefore, it is recommended that fish be consumed at least twice a week to meet dietary requirements (Vilain and Baran (2016). Additionally, pregnant, lactating and nursing women should eat fish to avoid the risk of neurological development in children (Vilain and Baran, 2016). Fish also contains Polysaturated fatty acids (PUFA) including Docosahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA) which are important for the good health of the human heart and reduce the risk for premature birth in pregnant women (Imhoff-Kunsch *et al.,* 2012; Zhao *et al.,* 2016). Therefore, the availability and accessorily of inland fish make it important to fight hunger and malnutrition.

Globally, the fish per capita is estimated at 20kg with South African standing at 6-8kg (SAGov, 2018). Fish contribute to the daily protein intake. This is because the consumption of fish is seen as a healthy source of protein and minerals. With the persisting challenge of food insecurity, malnutrition, poverty and unemployment in South Africa, inland fisheries are recognised as one of the sectors to curb this problem. In addition, inland fisheries play a significant role in achieving 2030 Sustainable Development Goal 1 and 2, that is No Poverty and Zero Hunger respectively (Lynch *et al.,* 2020).

Given this information, fish is a cheap source of protein in South African rural poor households and has been found to contain micronutrients and macronutrients which are essential for human development (Balami *et al.,* 2019; Mohanty *et al.,* 2019; FAO, 2020). This, therefore, makes inland fish a valuable source of nutrition for both rural and urban households. Although most poor households in South Africa rely on government assisted social grants still, these households are unable to afford a

balanced diet and face food insecurity shocks (Govender *et al.,* 2017). Henceforward, from a nutritional point of view, consumption of inland fish has the potential to provide more micronutrition for the rural poor (Bogard *et al.,* 2015). The summary of the minerals, micro- and macro-nutrients benefits from inland fish and its importance for human health are presented in Table 2.1., 2.2., and 2.3.

Table 2.1: Minerals available in inland fishes and importance to human health.

Type of mineral	Importance to human health	References
Iron	Helps transport oxygen to parts of the body	Mohanty *et al.,* (2019); Vilain and Baran (2016); Kwasek *et al.,* (2020)
Zinc	Boost growth boosts immune growth	Mohanty *et al.,* (2012); Vilain and Baran (2016); Kwasek *et al.,* (2020)
Calcium	Promotes good growth of bones and normal functioning of the nervous system	Balami *et al.,* (2019); Athauda *et al.,* (2016)
Iodine	Reduces the risk of goitre and mental impairment	Vilain and Baran (2016); Athauda *et al.,* (2016),
Selenium	Reduces antioxidants enzymes, immune functions	Balami *et al.,* (2019); Kwasek *et al.,* (2020)
Phosphorus	Improve bone and teeth, boosts energy	Vilain and Baran (2016)
Potassium	Reduces the risk of heart diseases, improves blood pressure and muscle control	Vilain and Baran (2016)

Source: Own compilation (2021)

Table 2.2: Micronutrients available in inland fishes and importance to human health.

Type of micronutrient	Importance to human health	References
Vitamin A	Helps maintain normal growth, promoted the development of bones	Pal *et al.,* (2018); Vilain and Baran (2016); Kwasek *et*

	and teeth helps prevent eye problems	*al.,* (2020); Thomson *et al.,* (2008)
Vitamin B12	Helps in the development of the brain and nervous system	Bogard *et al.,* (2015); Vilain and Baran (2016)
Vitamin D	Boost metabolism, important for brain health, promotes strong muscles	Athauda *et al.,* (2016); National Institute of health (2021)
Vitamin E	Reduces the level of inflammation, joint swelling and tenderness limits the risk of diabetes, cardiovascular disease and cataracts	Vilain and Baran (2016)
Folate	Assist in the growth of the foetus during pregnancy, reduces the risk of anaemia	Bogard *et al.,* (2015); Krauss-Etschmann *et al.,* (2007)

Source: Own compilation (2021)

Table 2.3: Macronutrients available in inland fishes and importance to human health.

Type of macronutrient	Importance to human health	References
Protein	Building and repairing muscle tissue fight bacterial and viral infections	Balami et al., (2019)
Docosahexaenoic acid (DHA)	Promotes healthy heart and good mental health reduce the risk for premature birth, lowers blood pressure	Imhoff-Kunsch *et al.,* (2012); Zhao *et al.,* (2016), Vilain and Baran (2016)
Eicosapentaenoic acid (EPA)		

Source: Own compilation (2021)

2.9. Determinants of households' food security

Food insecurity has emerged as a global crisis that has since affected individuals and households in different ways. Despise this information, the food security situation of

households across the globe depends on various factors such as socio-economic characteristics of households and institutional factors. Various food security measures have been used to estimate households' food security status. Ngema *et al.,* (2018); Awoke *et al.,* (2022), for example, used the Household Dietary Diversity Score as a proxy to assess food security status in Maphumulo Local Municipality. Ndobo (2013) assessed the food security status of households in a South African township using the Household Food Insecurity Access Scale (HFIAS). Other authors, including Akukwe (2020), employed the Household Food Security Index (FISI) to measure the food security status of households.

Authors such as Ngema *et al.,* (2018) investigated the food security status and determinants in Maphumulo Local Municipality. The study focused on the food security status of One-Home-One Garden (OHOG) beneficiaries against non-beneficiaries. The binary logistic model was employed to analyse the data. The results revealed that education, receiving infrastructural supports and participation in the OHOG programme positively influence the food security status of households. However, variables such as household income and access to credit showed a negative correlation. Similarly, Awoke *et al.,* (2022) explored the determinants of food security status of households in Central and North Gondar Zone, Ethiopia using binary logistic model. The results showed that the household food security status is determined by age, access to training, sex, family size, number of oxen, off-farm, farmland size and household income.

Akukwe (2020) studied the household food security and its determinants in agrarian communities of South-eastern Nigeria. Stratified and random sampling methods were used to sample four hundred households. The logistic regression showed that there is a relationship between food security status and marital status. Further, level of income, dependency ratio and monthly income were found to be significant. On the other hand, institutional variables such as distance to the market was negatively correlated with food security suggesting that households residing closer to the market are likely to be food secured.

On the other hand, gender of the household head plays an important role as a determinant of food security. For example, Dunga (2020) used the Household Dietary Diversity Score (HDDS) to estimate the food security status of female headed

households in South Africa. As the dependent variable, the HDDS was calculated as continuous variable. The results show that being involved in agricultural activities increases the probability of being food secure among female-headed households. The implication is that participating in agricultural activities increases the chance of producing own food and improving dietary diversity. Thus, Nagese *et al.,* (2020) established through literature that female-headed households are more prevalent to food insecurity compared to male-headed households. However, agriculture plays an important role in alleviating household food insecurity and poverty ultimately eliminating hunger (Pawlak and Kołodziejczak, 2020).

Olaoye *et al.,* (2021) also studied the socio-economic determinants of household food security among fish farmers in Odogbolu local government area of Ogun State, Nigeria. Although the study established that fish farming contributes to household food security through increased income and dietary diversity, the analysed results agree with prior findings that age and household size significantly determine the food security status of fishing households. Other authors agree that socioeconomic factors such as gender, age, level of education, fishing experience of the household head, household income, and the number of employed household members all have a significant impact on the food security status of households (Ndobo, 2013; Tibesigwa and Visser, 2016; Jeyarajah, 2018, Akukwe 2020).

On the other hand, Himi *et al.,* (2021) analysed the determinants of food insecurity status of fishing communities in coastal regions of Bangladesh by also employing the logistic regression model. The study's findings revealed that large households are more likely to be food insecure than small households. Moreover, educational level of the fishers also influences their food insecurity status. This means that when the fishers' level of education rises, they will be able to reduce their food insecurity situation through acquiring more fishing skills. To this end, the determinants of food security depend on socio-economic characteristics and institutional factors.

2.10. Role of women in fisheries

Fisheries is a sector that involves both men and women yet, these roles may be distinct based on various factors. For instance, in Bangladesh, particularly in the Padma River, females are restricted to be involved in fishing activities (Sunny *et al.,* 2019). This is

because fishing is often seen as a male-dominated activity but, women also play various important roles particularly in small-scale fisheries [World-Wide Fund for the Nature United Kingdom (WWF-UK), 2012).

Despite some form of restrictions, according to WWF-UK, (2012); Nwabese *et al.,* (2013); FAO (2014), women are responsible for most of the time-consuming tasks performed offshore. These include making and mending nets, making buckets, baiting hooks and pots, processing and marketing of the fish. Mostly, these activities are rendered as a non-paid task hence the work of women in fisheries is rarely recognised (FAO, 2014; Ogden, 2017). Likewise, various studies have reported that the role of women in fisheries is at times undervalued, uncredited and underappreciated by society, policymakers and the fisheries' sector (Harper *et al.,* 2013; Harper *et al.,* 2020). Hence, there is a lack of clearly defined gender roles and responsibilities within fisheries thus, the contribution of fisheries to livelihoods is underestimated.

Previous studies have reported that not only are women involved in pre-and post-harvesting activities, but they also serve as a source of information, bookkeepers for household fish enterprises, management of fisheries and, practical backup in fisheries (such as picking up fishing equipment and fishing labourers particularly when the spouse is off fishing) [Kusakabe, 2002; MacAlister and Partners, 2002; Suntornratana, 2002; WWF-UK, 2012]. For example, unlike men, women will fish for almost all seasons since they are responsible for maintaining household protein food supply. Moreover, women might fish for both food security and income generation while men are likely to fish for income generation. Hence, women might have more information about fish as compared to males (Kusakabe, 2002; Suntornratana, 2002). As a result, both men and women play complementary roles in the fishing sector. For instance, it is also reported that women are likely to be involved in fisheries due to the involvement of spouses in fishing hence they play a role in post-harvest activities such as marketing (Suntornratana, 2002). This suggests that women perform a meaningful role in the value chain of fisheries.

Raemaekers and Sunde (2015) confirm that women in Africa are engaged in both pre-and post-harvesting activities however, their roles remain invincible. Another study accentuates that, women also hire men to fish on their behalf while their role is mostly linked with post-harvesting activities (Limuwa, 2019). To this end, it could be said that

women are mostly involved in post- and pre-harvesting activities with few participations in the actual fish harvesting.

Women are also involved in aquaculture and marine sectors (Du Preeze, 2018; Harper *et al.,* 2020). However, women face discriminatory practices and inequality within the fisheries' sector (Du Preeze, 2018). This is attributed to various factors such as lack of land, less access to social and economic resources, limited participation in fisheries management and lack of institutional supports (Du Preeze, 2018). Thus, recognising and quantifying the role of women in fisheries has meaningful insinuation for management, poverty alleviation and policy development (Harper *et al.,* 2013).

According to de Graaf and Garibaldi (2014), in 2011 fisheries and aquaculture contributed $24 billion to the African economy. The different fisheries sector in the continent had their equal share of this contribution. For example, marine fisheries contribute 0.79% while, inland fisheries and aquaculture contributed 0.33% and 0.15% respectively. To this, 12.3 million people in Africa are employed in the fisheries sector with 55% working in inland fisheries, about 42% work in the marine artisanal fisheries as processors. The study showed that women are employed in almost half of the 26.7% of inland fisheries with the work of actual fishing accounting for 6.7% while processing jobs account for 69.7%. Within the marine sector, the study reported that 23.8% and 43.5% of women are involved in the marine artisanal and marine industrial sectors respectively. On the other hand, the proportion of women involved in aquaculture amounted to 4.8%.

Currently, investigations such as those done by Brugere and Williams (2017); Gopal *et al.,* (2020) emphasise that although women work in all sections of both inland fisheries and aquaculture value chains, these women often miss opportunities that exist within these sectors. For instance, when the aquaculture projects get successful, women are mostly moved to the less paying sections (Brugere and Williams, 2017). This, however, justifies that there is gender inequality within the aquaculture sector also. Harper *et al.,* (2020) estimate that women roughly account for 2.9 million tonnes of fish and invertebrates, particularly within the small-scale inland fisheries. On the other hand, the landed catch by women is estimated at $5.6 billion which contributes $14.8 billion to the global economy. However, some women mostly catch fish for subsistence purposes with surplus sold for income generation (Harper *et al.,* 2020).

Despite the vast contribution of women in fisheries, they are still unrecognised by the community, and policies are gender-biased (Funge-Smith and Bennett, 2019).

The current global fisheries scale estimated that in 2016, about 59.6 million people were engaged in both capture fisheries and aquaculture either on a full-time, part-time or occasional basis. In addition, 8.3 million of these workers were women (FAO, 2018a). Furthermore, it is reported that in Africa, about 11% of women were employed in both fisheries and aquaculture sectors as compared to 79% and 70% of males employed in fisheries and aquaculture respectively (FAO, 2018a). A survey conducted in South Africa found that only 16.4% of recreational fishers are females while males add up to 76.6% (the remainder being children) particularly within inland fisheries. The primary purpose of recreational fisheries is fishing for leisure, but participants might sell their catch (Ellender *et al.,* 2009). To this end, women play different roles in inland fisheries, marine, aquaculture and recreational fisheries.

Moreover, there is under-reporting of women's involvement in fisheries which, therefore, exacerbate the invisibility of women in this sector. For instance, earlier studies such as those conducted by Trottier and Fabrizi (1987) have recognised the vast participation of African women in fisheries. The study recognised that women carry out traditional fishing activities such as diving for oysters in Benin and Togo, produce shrimp and finfish in Guinea Bissau and Côte d'Ivoire. The study also reported that in countries such as Sierra Leone, fishing is mostly a women's job since men are not interested, whilst in Gabo, most of the canoes are operated by women. However, it is reported that most women go fishing when they have time due to the various household responsibilities (Trottier and Fabrizi, 1987).

Several surveys have outlined that males dominate most sectors of the community, farm business, household and subsequently, fisheries (O'Neil and Domingo, 2015; Enete and Amusa, 2010, Manyungwa-Pisani *et al.,* 2017). This may be subject to the patriarchal views of the society which has labelled women as secondary decision-makers. In consonance with previous and current research, Devkota *et al.,* (1999); Akhtar *et al.,* (2018) found that women are more involved in household management and family welfare activities than men. Nonetheless, these studies found that most households' decisions are made by both males and females. Diversely, Wambua (2013) states that not only are women involved in the household decision, but they

also participate in community-making decisions. However, this participation is influenced by their level of education. Enete and Amusa (2010) also attest that level of education plays a significant role in the participation of women in farm-decision-making. In addition, Manyungwa-Pasani *et al.,* (2017) assert that both men and woman are involved in the value chain of fisheries either as fishers, traders, retailing and as brokers. With that being said, women's dominance of the fish value chain is limited. This signifies that the roles of women have been changing over time and, policies should be gender-balanced to recognise the importance of females in household and community activities. Therefore, this can be achieved through women's participation in the decision-making process through improving their education and skills.

The challenge of not recognising women's roles in fisheries has many shortcomings. For instance, women are usually excluded in the fisheries decision-making process, have limited access to technology, ponds and inputs for aquaculture, lack access to credit, poor access to land, lack of transport facilities for their fish business, susceptible to criminal activities, unequal wages, social and cultural constraints, access to national, and global markets and are only recognised as supporting men in fishing activities (Williams, 2002; FAO, 2016; Gopal *et al.,* 2020; Harper *et al.,* 2020). An investigation by Mahmud *et al.,* (2017), attest that, women who received fishery training on fishery technology, fishery management and income generation activities tend to boost their contribution to the total household income by putting this skill into practice.

Consequently, most women are closely becoming involved in fisheries management, however, the highest positions such as policy and decision making are still held by men (Harper *et al.,* 2013). Gradually, women are venturing in fisheries strategic planning and capacity building roles, this then serves as one of the keys to poverty alleviation and food insecurity (Harper *et al.,* 2013). According to Tandavanitj (2008), the importance of fisheries management is that it can improve the adaptability and flexibility of both resource users and communities. This is because, women in fisheries emphasise the sustainability of the fishing resources. With that being the case, it is hard to ignore the significant role women play in fisheries.

2.11. Inland fisheries value chain and its role players

Inland fisheries have continued to grow over the past years. In 2011, about 11.1 million tonnes of inland fish was produced in the world (FAO, 2016). It then increased to 11.6 million tonnes in 2016 and 20 million tonnes in 2018 (FAO, 2018a; FAO, 2020). This indicates that undeniably, inland fisheries is an important sector that can contribute to food security and income generation particularly in developing countries. The World Bank (2012) reports that in developing countries, small-scale fisheries employ over 90% of individuals who fish mostly at the rivers, lakes and wetlands thus contributing to livelihoods. Therefore, these individuals are employed across the inland fisheries value chain.

It is projected that the global population will grow by 9.7 billion by the year 2050 (Béné *et al.,* 2015). The challenge stems from feeding this growing population and also achieving Sustainable Development Goals (Goal 2, 3, 6, 7 and 15) [Funge-Smith and Bennett, 2019]. There is therefore a need to channel the inland fisheries value chain to benefit household food security, employment, income generation particularly for poor households. With these being said, the benefits of the value chain in fisheries are the increased producer share, the minimum cost of the processes, increase in efficiency and effectiveness of the actors, boosts business and employment, eliminate the unwanted processes such as non-valuable addition, quality assurance in product development and to ensure customer satisfaction (Jeyanthi *et al.,* 2017; Burch and Maes, 2017). Additionally, the importance of the fish value chain is that it highlights enterprise development, enhances the quality of a product and qualitative measures of value addition, promotes coordinated linkages among producers and improves the competitive position of individual enterprises in the marketplace (Awel *et al.,* 2018).

According to FAO (2018a), Sustainable Development Goal 1 is dedicated to fisheries and fisheries value chain to support livelihoods of the poor and vulnerable with inclusive access to fisheries and related economic resources. Despite this information, in developing countries such as South Africa, it was found that the inland fisheries value chain is short and the roles of the actors are not clearly defined (Britz *et al.,* 2015; Sara *et al.,* 2017). This includes the roles played by rural households within the value chain.

First proposed by Porter (1985) as a vital tool to better understand all the elements that involve a firm's competitive advantage, value chain analysis helps to better comprehend the activities encompassed in a product or service until it reaches the final consumer. This concept involves a full range of activities that are required to bring a product or service from its conception, through the different phases of production, transformation and delivery to final consumers and eventually to its disposal use (Naji, 2013). That being the case, De Silva (2011) defined a fisheries value chain as an interlinked of value-adding activities that convert inputs into outputs which, in turn, add to the bottom line and help to create competitive advantage. The value chain approach is flexible and comprises all activities that directly or indirectly contribute to the capture, post-harvest processing and marketing of fish (Basurto *et al.,* 2017; Rosale *et al.,* 2017). Furthermore, the value chain is a descriptive tool to look at the interactions between economic agents (Rosale *et al.,* 2017).

Congruently, the fisheries value chain differs according to fish, country and region (De Silva, 2011). For instance, fish has many different species that can be prepared in different ways due to the rapid spoil, post-harvest handling, processing, preservation, packaging, storage and transportation. Preservation and processing can reduce the spoilage rate (Ward and Beyens, 2015). Value chain, in this case, focuses on all the necessary steps that fishery business goes through from raw materials until it reaches the end-user and includes all economic activities and subsectors (De Silva, 2011; World Bank, 2012). The value chain includes producers, input suppliers, operations, processors, retailers and buyers and it also plays an important role in determining the quality, quantities, prices and timing for the success of the products or services (Kumar and Rajeev, 2016). These actors can be grouped into value chain actors/players, value chain influencers and value chain supporters.

Value chain players are those who are directly involved in the value chain activities by transforming the physical product into the final product (Stein and Barron, 2017; Muchopondwa *et al.,* 2021). Therefore, value chain analysis involves understanding the linkage between different activities and actors that are involved to bring a product from production to consumption (Stein and Barron, 2017). Moreover, Jeyanthi *et al.,* (2017), adds that value chain analysis consists of various constraints and issues such as infrastructure facilities, input supply, credit facilities, quality and safety standards, international regulations and middlemen intervention. The key component in value

chain analysis is mapping the value chain. This is because, mapping the value chain makes it easy to track and analyse the relationship between different actors and their functions (Dubey *et al.,* 2020). Adding to that, mapping the value chain with its different components, linkages and actors can facilitate a structured discussion about the opportunities and constraints that producers and other actors face and the possible solutions (Stein and Barron, 2017).

The linkages of the value chain are the channels/patterns/relationships that connect the different value chain activities and through which a product passes from the design to the consumption stage. Pedroza-Gutierrez and Lopez-Rocha (2016) identified three patterns for the inland fisheries value chain in central Mexico. Firstly, it was identified that fisheries play a subsistence role because the household of the fisher consumes some of the fish and, the fisher or wife sells the rest for the final consumer. Secondly, the fisher sells fish by the lakeshore to middlemen or restaurants who will sell to the final consumer. The last pattern includes a long and complex case where the fish passes through intermediaries, to wholesalers, to an urban market, and finally, to a consumer.

Several authors have highlighted that fishing households play multiple roles and functions along the fisheries value chain. For example, Alemu and Azadi, (2018) found that fishing households in Northern Ethiopia play numerous roles as fisher, processor, seller, and consumer. In a study by Nasr-Allah *et al.,* (2019), three main actors in the fish value chain were identified. These include fishers, traders (intermediaries, wholesalers, and retailers) and fish processors. Saagulo *et al.,* (2017) examined factors that influence people's decision to participate in fishery-related activities along the Volta Lake in Yeyi, Ghana. The study found that fisher's function as fish harvesters, processors, marketing, fishnet weaving/mending/repairing and fish consumers.

Saagulo *et al.,* (2017) identified the factors that influence people's decision to go fishing. Four main fishery-related activities were identified, that is fish harvesting, fish trading, fish processing and net making/mending. As one of the post-harvesting activities, fish processing adds value to the fish and creates employment especially for women across the globe (Welcomme *et al.,* 2010). In Malawi, it was found that women are fairly integrated into all the nodes and activities of the fish value chain (Manyungwa-Pasani *et al.,* 2017). However, women participation in the fish value

chain has been prompt by cultural, social, economic and political factors (FAO, 2014). On that account, the value chain of inland fisheries is important in identifying opportunities that households can engage in so to promote food security, employment and income generation. Moreover, the inland fisheries value chain indicates the relationship between fisheries management and the users of the inland fisheries resources to promote sustainability for current and future beneficiaries.

2.12. Conceptual framework

This study is aimed at assessing the contribution of inland fisheries to income generation and food security. Therefore, a conceptual framework is adapted to understand the contribution of inland fisheries to income generation and household food security. The framework explains the general consumption of inland fish, contribution to livelihoods through food security and increasing household income. The conceptual framework is summarised in Figure 2.1.

2.12.1. Production of inland fisheries

Worldwide production of inland fisheries accounts for 12.5% from a total of 16 countries reporting to produced more than 80% of global inland fish catches (FAO, 2020). Asia has been recognised to produce more inland fish across the globe since the mid-2000 (FAO, 2020). However, inland fisheries are also important in the African continent and account for 25% of global inland catches. In 2018, the global inland fish catches reached over 12 million tonnes which show an increase from the 1990s. In addition, China, India, Bangladesh, Myanmar and Cambodia have been recognised as the top producers of inland fisheries across the globe (FAO, 2020). This is attributed to the reporting of catches by these countries (Funge-Smith and Bennette, 2019). The major fish species caught in inland waters are Carps, Barbels, other cyprinids. On the other hand, Tilapias and other cichlids had a small increase from the 2000s to 2018 (that is from 0.7 million tonnes to 0.85 million tonnes per year) [FAO, 2020].

Poor data reporting by countries has been recognised by FAO as a challenge that hinders the inland fish catch reports. This challenge stems from reporting errors, non-reporting, overreporting and incomplete recording (Funge-Smith and Bennette, 2019). Therefore, inland catches for subsistence and recreational purposes have been underreported (Funge-Smith and Bennette, 2019). South Africa is not an exception.

For example, there has been underreporting of fish caught within the inland waters (Welcomme and Lymer, 2012). Moreover, for the historical catch of inland fisheries in South Africa from 1950 to 2007, the annual changes have not been greater than 30% (Welcomme and Lymer, 2012). Also, the number of fish harvested by households for consumption or selling is not reported. In some instances, poaching is practised which threatens the sustainability of the fish. However, the marine sector in South Africa has been recognised to be the best-performing fish harvest and post-harvest sector (Asche *et al.,* 2021).

Despite this, evidence of the existence of inland fishing activities in South Africa has been recognised by various authors such as McCaffety *et al.,* (2012); Tapela *et al.,* (2015); Britz *et al.,* (2015); Nibamureke *et al.,* (2016); Sara *et al.,* (2017); Hara *et al.,* (2021). With that being said, the production of inland fish provides an opportunity for the improvement of livelihoods in South Africa and across the globe.

2.12.2. General consumption of inland fish

Inland fisheries are known to play diverse roles all over the globe. These roles range from alleviating poverty, improving food security, gender empowerment, cultural services, ecosystem function and biodiversity (Funge-Smith and Bennett, 2019). In addition, fish plays an important role in the diets of humans across the world and is estimated to provide 60% of the protein needed by people (Onumah *et al.,* 2020).

According to Tilami and Samples (2017), it is recommended that people consume fish two times per week. On a report by FAO (2020), generally, fish consumption renders humans with lowering the risk of heart diseases and stroke. Consumption of fish is also essential for pregnant woman due to its high omega-3 content which is important in foetal development moreover, the nutritional content of fish is significant in the first 1000 days of a child's life (Bunthang *et al.,* 2016; Toppe, 2021).

About 90% of fish from the inland waters are used for local and direct consumption (Funge-Smith, 2018). Therefore, factors such as availability, taste, price, nutrition, fishbone, type of fish, convenience in fish preparation and safety concerns contribute to consumers' choice, behaviour, frequency and attitude contribute towards fish consumption (Uzundumlu *et al.,* 2015; Jayasinghe *et al.,* 2019). Can *et al.,* (2015) indicate that consumers' socioeconomic characteristics also affect the consumption

behaviour of fish. Although fish is a perishable food, its market is diverse with locations based on different geographical areas with various climatic conditions.

In a recent study conducted by Abdikoğlu and Unakitan (2019) in Takirdag Province in Turkey, it was found that purchasing factor, health benefit factor, consumer income and level of education are factors that affect the consumption effect of fish consumers in the study area. Scientific evidence illustrates that fish is mostly regarded as healthy food and reduces the risk of heart diseases. Additionally, in Sub-Saharan Africa, the demand for fish outweighs the supply (Tran *et al.,* 2019). However, the consumption frequency of fish differs among individuals. For instance, in Sub-Saharan Africa, the demand for fish outweighs the supply (Tran *et al.,* 2019). This is because fisheries are known to play diverse roles all over the globe particularly inland fisheries. Relating to the consumption benefits obtained from consuming fish from inland waters, research by Bedada and Lemma, (2017); Amenyogbe *et al.,* (2018); Mohanty *et al.,* (2019); Onumah *et al.,* (2020) confirm that inland fish is inexpensive, available for all income groups, provide vitamins and minerals which are needed to sustain good health and reduces the chance of infections.

2.12.3. Contributing to livelihoods through food security and income

Fish is acceptable by all as food regardless of age, gender, religion or region. Inland fisheries is one of the oldest approaches used to access food and nutrition (Gurung, 2016). The reason behind this acceptance lies in the accessibility of fish as a cheap source of protein (Onumah *et al.,* 2020). Moreover, inland fish contains micro-and macro-nutrients (Funge-Smith, 2018). In many parts of the world, inland fisheries are the primary source of animal protein and important to ensure food and nutritional security at the local and regional level particularly in developing countries (Youn *et al.,* 2014). Although evidence of inland fisheries contribution to food security has been outlined, there is however poor data availability which therefore overshadows the importance of inland fisheries to food security (Béné and Neiland 2003; NEPAD Policy Brief Six, 2016). Despite this, the contribution of fish to rural livelihoods through food security has been highlighted in recent and previous studies. Thus, most people participate in inland fisheries for subsistence, artisanal and commercial (Welcomme, 2011).

According to Kawarazuka (2010), fish is more nutritious compared to stable foods by providing animal protein, essential fatty acids and micronutrients. In as much as fish contributes to food security, different inland fishing activities also contribute to household income. For example, fish from the inland can be sold raw or processed which will, in turn, generate income (Hara *et al.,* 2021). According to Budaza (2018), the income that comes from fisheries boosts the purchasing power of households which in turn serves as a source of household income. Although commercial inland fishing in South Africa is not recognised, the majority of small-scale fishers sell for income generation (McCaffety *et al.,* 2012). Therefore, an opportunity for households to participate in inland fisheries for small-scale purposes exist to generate food and household income.

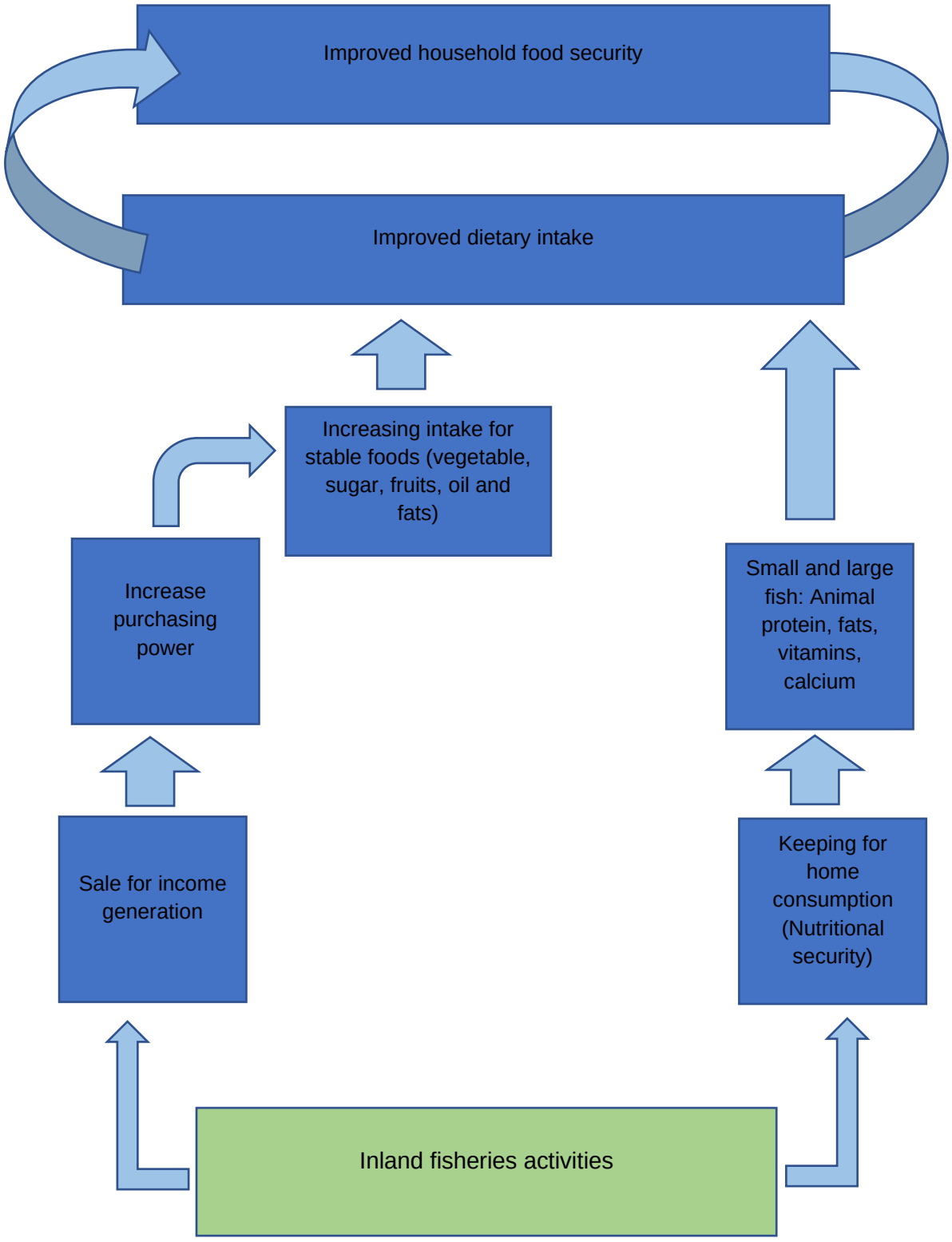

Figure 2.1: Conceptual framework adapted

Sources: Author's compilation and adapted from Budaza (2018)

2.13. Summary of literature review

It is therefore without a doubt that inland fisheries are significant internationally, locally and at a household level. The reviewed studies have revealed the importance of inland fisheries for food security, nutrition and income generation. Moreover, it cannot be disputed that both men and women play vital roles in the inland fisheries value chain. However, the contribution of women is overlooked by policies and the general community. Moreover, the involvement of women in this sector not only boost household income but also contribute to the alleviation of poverty, unemployment and reduces household food insecurity shocks.

Given all, fishing supports livelihoods worldwide, however, the support differs by location and socio-economic factors. Moreover, inland fisheries play an important role in the livelihoods of the rural poor. Thus, the contribution of fisheries to total household income gives households access to other benefits such as education, health services and income to purchase food items. Moreover, the contribution of inland fisheries to household income serves as a safety net and enable households to diversify their diets.

Evidence of the contribution of fishing to employment, food security and nutrition was observed in the reviewed literature. It is important to note that inland fisheries directly supply households with fish for consumption and selling. Either way, the household participate in inland fisheries on a small-scale, recreation, subsistence scale or commercial scale.

It can be argued that most households that fish for consumption are poor. However, most small-scale fishers participate for market purposes and the surplus is consumed or given to neighbours or other family members. The concept of livelihoods can be thought of as how people make a living, therefore, the significance of fisheries to income generation and food security is important in enhancing rural livelihoods. Although inland fisheries are being overlooked as an important sector for income generation and food security, the reviewed surveys provide a glimpse of the importance of this sector to rural livelihoods and the economy at large.

The studies reviewed also provide evidence that although fishing is an economic activity for some households, other non-fishing economic activities also create

opportunities for income generation and food security. Therefore, it can be said that fishing is an activity that can be combined with other jobs which will serve as multiple livelihood strategies.

CHAPTER THREE

DESCRIPTION OF STUDY AREA, RESEARCH METHODOLOGY AND ANALYTICAL PROCEDURES

3.0. Introduction

This chapter is aimed at describing the study area, research methodology and analytical procedures used. It starts by outlining the specific locations where the study was conducted followed by the ecological status of the study areas such as rainfall and temperature, vegetation and description of inland fisheries resources. Furthermore, the chapter focuses on the research methodologies and analytical procedures adopted in the study. Thus, the research design, sampling procedures and analytical models used to achieve the objectives of the study are discussed in this chapter.

3.1. Limpopo Province

Limpopo is the landlocked and northernmost province of South Africa, and it is known as the gateway to Africa because it borders countries such as Mozambique to the east, Zimbabwe to the north and Botswana to the west. The province also shares provincial borders with Mpumalanga, Gauteng and North-West Provinces to the south. The province constitutes five district municipalities namely, Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg. These district municipalities share twenty-two local municipalities (MSA, 2020).

Formerly known as Northern Province before the year 2002, the Limpopo Province is ranked fifth in South Africa in terms of surface area, and population and covers around 125 754km² of land (Stats SA), 2016]. The provincial capital city of the province is Polokwane, which was previously known as Pietersburg. However, there are other important urban centres such as Bela-Bela (also known as Warmbath), Makhado (also known as Louis Trichardt), Mokopane (also known as Potgietersrus), Mussina (also known as Messina), Phalaborwa, Tubatse, Tzaneen and Thabazimbi [Municipalities of South Africa (MSA), 2020].

The Limpopo Province comprises mostly of rural communities with different ethnic groups. The biggest ethnic group is the Ba-Pedi which accounts for more than half of

the population, followed by Va-Tsonga and Vha-Venda. The Afrikaans group consists of small percentages while English is regarded as a language used during business interactions.

The Economic Development Department (EDD) which was developed after the 2009 elections, aims to transform the economy by employing a large number of people (EDD, 2016). To this end, agriculture, tourism and mining in the Limpopo Province have been recognised as economic contributors to achieving this mandate. For instance, the Limpopo Tourism Agency's mission is to promote and offer a quality, sustainable and devise tourism experience, hence, the province received 18.3% of international tourists in 2017 (Department of Tourism, 2016/2017). Likewise, the tourism sector in the province employs more than 100 000 people and contributes 0.27% to the South African Gross Domestic Product (Department of Environmental Affairs, 2018).

The Limpopo Province has numerous wildlife and nature conservation areas such as Nylsvley Nature Reserve, Mapungubwe National Park, Kruger National Park and Marekele National Park (Lombaard *et al.,* 2015) hence, the province is regarded as one of the top three hunting provinces in South Africa (Van der Merwe *et al.,* 2014). Likewise, the Kruger National Park is one of the most visited national parks in Africa with over 1 million visitors per year (Brett, 2018; South African National Parks, 2016/2017). Therefore, the diversity of the tourism sector in the province offers various employment opportunities for its residents.

Agriculture is an important key contributor to the economy of the province. For instance, the sector contributes 8.6% to the South African GDP and 10% to employment. This might be credited to the fact that the province is the largest producer of tomatoes in South Africa (DAFF, 2017). Moreover, Limpopo's fruit and vegetable production contribute to the South African export market with 45% of the product reaching the Johannesburg Stock Exchange (Limpopo Business, 2019/2020).

On the other hand, the mining sector constitutes about 24.5 % of the provincial GDP and in 2016 it accounted for 6% of total employment (Limpopo Business, 2019/2020; Limpopo Provincial Treasury, 2018/2019). Simultaneously, there are over 147 operating mines in the province, which are mainly for the extraction of coal, copper, diamond, gold, iron ore, nickel, platinum group metals, rare earth minerals and tin.

This industry provides employment opportunities for residents of the province, resulting in an increase in employment from 71 000 in 2013 to 103 000 in 2017-2018 (Limpopo Business, 2019-2020). Nevertheless, Limpopo province is the second most impoverished province in South Africa, and the unemployment rate in 2016 was 19.6%. Additionally, there has been an increase in the intensity of poverty between 2011 (41.6%) and 2016 (42.3%) [Stats SA, 2016]. Lately, the unemployment rate of the province is reported at 20.3% with 21.8% of households living in poverty (Sicetsha, 2019; Stats SA, 2019).

Water is one of the scarce resources in South Africa and eventually in the province. Consequently, the usage of water is important for the sustainability of life, agriculture, aquatic organisms and the economy. The districts of the province have a huge number of households with no access to water, thus presenting a challenge to the growing population (Limpopo Provincial Treasury, 2018/2019). However, the backlog of water provision (service delivery), pollution and drought give rise to the limited water supply in the province (Lombard, 2019). In view of these, residents residing closer to rivers and having no access to piped water or borehole's make use of the water from the rivers for domestic use. Eventually, these households take on the advantage of fishing at these water bodies.

The province has perennial rivers such as the Matlaba River, Mokolo River, Lephalale River, Mogalakwena River, Sand River and Nzhelele River which form the six catchment areas. With other small tributaries, the rivers flow northward and are discharged into the Limpopo River (Lombaard *et al.,* 2015). Subsequently, inland fisheries within the Limpopo Province have been identified by several authors (Tapela *et al.,* 2015; Phosa and Lethoko, 2018; Hara *et al.,* 2021). Although there is no available data on the quantity of inland fish caught in the province, these studies suggest that inland fisheries have significant importance to the livelihoods of rural households. Moreover, there are 464 registered dams in the province [Department of Water and Sanitation (DWS), 2020]. Except for privately owned water sources such as those from private farms, water sources that are owned by the government entities such as the Department of Water and Sanitation, play several roles. For example, the Flag-Boshielo dam supplies water for domestic, irrigation and mining use.

Even though fishing takes place in the majority of the dams and rivers in the province, inland fishing was not one of the factors that contributed to the building of the dams. Despite this, the introduction of fish species in these dams posed an opportunity for households to obtain some proteins. However, Britz *et al.,* (2015) confirm that little information exists on the degree of inland fisheries' contribution to the livelihoods of fishing communities. For example, the economic sectors in the province do not quantify the degree to which inland fisheries contribute to food security and income generation.

Unlike the marine sector, inland fisheries do not have a ministry of their own hence, it has been identified that the lack of an inland fisheries policy contributes to the sector being neglected as a contributor to rural livelihoods (Ellender *et al.,* 2010; Kotzé, 2015). Another opportunity presents itself for the inland sector to be recognised as a contributor to livelihoods through food security and income generation. Hence, the Limpopo Department of Economic Development, Environment and Tourism (LEDET) can support Small, Medium, and Micro Enterprises venturing into inland fisheries through the provision of fishing gear, training and buying fishing licences for households and individuals.

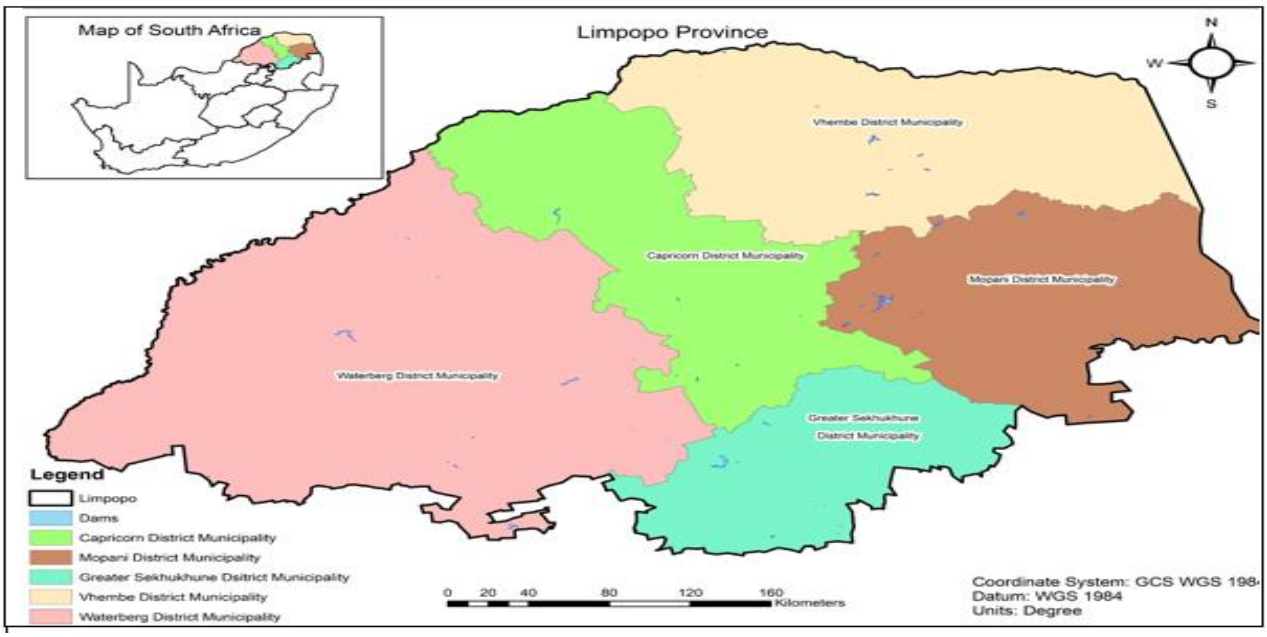

Figure 3.1: Map of Limpopo Province

Source: Arc GIS 10.7.1

3.2. Selection of districts for the study

The Limpopo Province is home to a population of 5 799 090 with 1 601083 rural households [Statistics South Africa (Stats SA), 2016] and consists of five district municipalities namely, Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg. Inland fisheries in the province occur across all these districts. However, this study only focused on Sekhukhune, Mopani and Vhembe District Municipalities. These three district municipalities were selected based on their distinct characteristics. For example, these districts constitute large dams in the province such that, in the Sekhukhune District Municipality, Da Hoop and Flag-Boshielo dams are considered the largest dams (Sekhukhune District Municipality IDP/Budget, 2011/2012-2015/2016; SDM IDP, 2017-2018). Nondoni Dam and Tzaneen dam are considered the largest dams in the Vhembe and Mopani Districts respectively (SAGov, 2014).

Although inland fisheries occur in Capricorn and Waterberg Districts, these two municipalities are viewed as urban dominated districts. For instance, Flora Park Dam in the Capricorn District Municipality is in Polokwane which is the capital city of the province. Moreover, the dam is mostly visited by communities for leisure. Chuniespoort Dam on the other hand is a medium-size dam that hosts fishing for both subsistence and recreational activities. However, payment is required to access this dam. In the Nkumi Dam, some fishers are unwilling to fish there because of the small size of the fish (Tapela *et al.,* 2015). Moreover, some of the local municipalities in the Capricorn District are characterised as urban than rural (Stats SA, 2021).

In Waterberg District Municipality, the quality of the water is said to increase the impact of fish mortality due to oxygen concentrations in aquatic environments and temperature (Waterberg IDP, 2020/2021). Moreover, dams such as the Doorndraai Dam in the Waterberg District Municipality are mostly utilised for recreational purposes, thus payment is required. Mogol Dam which is below the Mokolo Dam is inaccessible to the public due to some privately owned farms around the river (Rudolph, 2017). Again, Mokolo, Doorndraai and Rust de Winter dams in the Waterberg District Municipality are viewed as weekend getaway camp destinations (Waterberg District Municipality, 2021).

Additionally, SDM, MDM and VDM are characterised by the highest number of people with no education, are the poorest districts in the province and, there is confirmation

of current inland fishing activities (Stats SA, 2014; Tapela *et al.,* 2015; World Bank, 2018; Limpopo Provincial Treasury, 2018/2019). Current community survey results show that these three districts constitute a high number of people who access water from streams, rivers or flowing waters (Stats SA, 2016). For instance, about 53%, 24% and 18% of the households in SDM, MDM and VDM access water from the mentioned sources respectively (Stats SA, 2016). Therefore, the possibility of fishing also exists while these households fetch water for household consumption therefore, a better representation of inland fisheries for income generation and food security could be estimated from these three district municipalities.

3.3. Sekhukhune District Municipality (SDM)

3.3.1. Overview of Sekhukhune District Municipality (SDM)

Named after the King of the Bapedi tribe (King Sekhukhune), the Sekhukhune District Municipality was established in the year 2000. The SDM is situated in the southern-eastern part of the Limpopo Province and covers an area of 13 264 square kilometres. The district constitutes 764 villages and 117 wards. Most people in the district speak Sepedi (83%) as their home language while 4.4% speak IsiNdebele, 0.22% speak English and 0.83% speak Afrikaans [Sekhukhune District Municipality Integrated Development Plan (SDM IDP), 2019/2020]. Although the SDM is known for its majestic mountains and lush valleys, it is the smallest district in the province and comprises four local municipalities namely: Elias Motsoaledi, Ephraim Mogale, Fetakgomo Tubatse and Makhudumathamaga Local Municipalities.

The district receives 80 percent of its rainfall between November and March and the average temperature is 23 degrees Celsius with a maximum of 28 degrees Celsius and a minimum of 18 degrees Celsius. In winter, the average temperature is 13.5 degrees Celsius with a maximum of 20 degrees Celsius and a minimum of 7 degrees Celsius. Hence, the district has warm moist summers and cool dry winters [Department of Rural Development and Land Reform (DRDLR), 2016] which are suitable for fish production

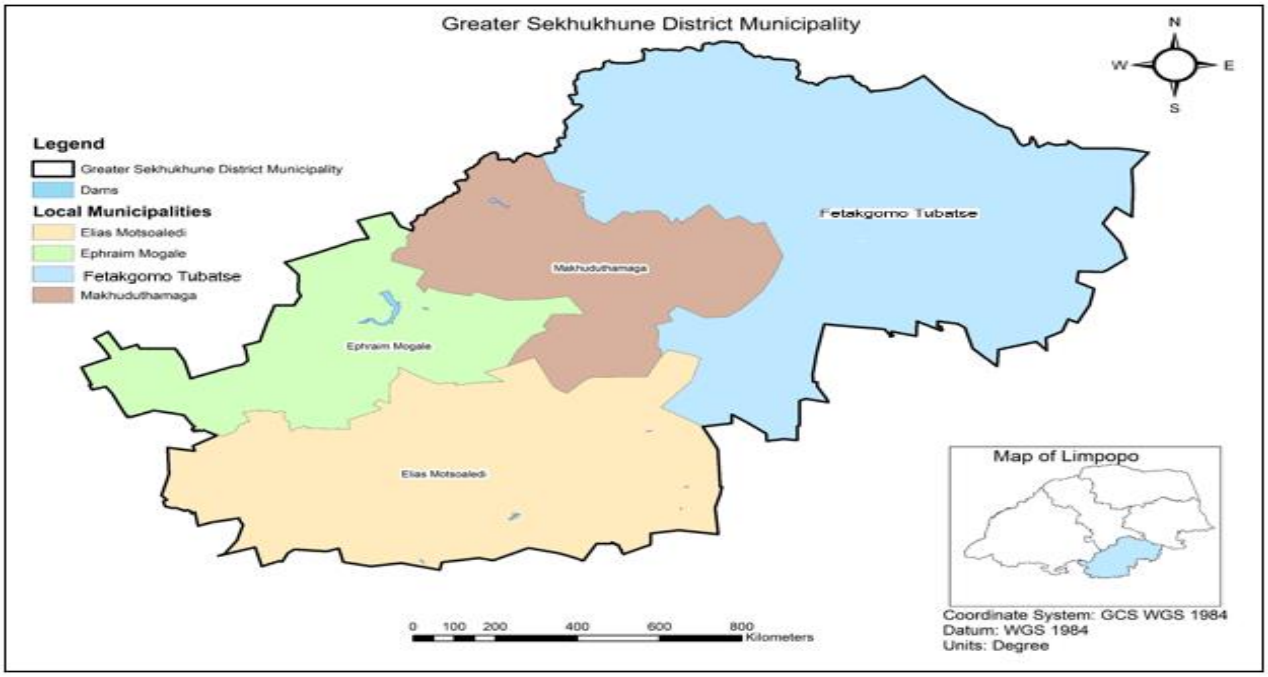

Figure 3.2. Map of Sekhukhune District Municipality

Source: Arc GIS 10.7.1

3.3.2. Main economic contributors in Sekhukhune District Municipality

a) Agriculture

The agricultural sector in the district is dualistic and consists of commercial and subsistence farming. Although agriculture is the second-largest source of employment in the district, it is the largest cluster of commercial farming in South Africa. The land of the districts is suitable to produce citrus fruits, table grapes, vegetables, maize, wheat, potatoes (both Irish and sweet) and cotton. Farmers in the district also engage in livestock production. However, the scarcity of water and uncertainty about land claims, hot and dry climate, serve as challenging factors in the agricultural sector of the Sekhukhune District Municipality [Sekhukhune District Municipality Integrated Development Plan (SDM IDP), 2016-2021]. Despite this, the agricultural sector in the district contributes approximately 9.7% to the aggregated GDP of the district.

b) Mining

The Sekhukhune District is home to a variety of mining activities including over seventeen (17) operational mines located along the R35 and R555 roads (Dilokong Corridor). The SDM thrives as the Limpopo Province's mining port, thanks to the extraction of andalusite, asbestos, chromite, and platinum. Anglo Platinum, Xstrata,

BHP Billiton, Implants, Asa metals and Marula Platinum are among the major mining companies in this district. The mining sector in this district accounts for approximately ± 2.38% to the GDP (SDM IDP, 2019/2021).

c) Tourism

Among the game farms and nature reserves in the Sekhukhune District Municipality are Potlake, Moutse, Schuinsdraai and, Loskop Dam Nature reserves. Cultural attractions in the district include Tjate, Lenao la Modimo, Ledingwe Cultural village and Echo Stones (DRDLR, 2016). Dams such as Flag-Boshielo and Da Hoop not only provide water but may also be used for recreational fishing. The recent development of the Kamoka Open Africa Route may also benefit district's tourism business. Currently, the tourism industry in the region employs approximately 962 people (SDM IDP, 2016-2021).

3.3.3. Potential of inland fisheries in the Sekhukhune District Municipality

Studies conducted by Britz *et al.,* (2015); Tapela *et al.,* (2015); Hara *et al.,* (2021) have established that there are fishing activities that take place in the Sekhukhune District Municipalities. Dams and rivers are used for recreational, small-scale, and subsistence fishing, in addition to fish farms (aquaculture). For example, there are over a hundred freshwater fish species in South Africa (Fish the Sea, 2020). With that being the case, various fish species have been discovered in the rivers and dams of the Sekhukhune District Municipality. For example, Sara *et al.,* (2017) found fish species such as *Clarias gariepinus, Coptodon rendalli, Cyprinus carpio, Enteromius rapax, Enteromius trimaculatus, Labeo cylindricus, Hypophthalmicthys molitrix, Labeobarbus marequensis, Labeo rosae, Marcusenius pongolensis, Micralestes acutidens, Micropterus salmoides, Oreochromis mossambicus, Pseudocrenilabrus philander, Schilbe intermedius, Synodontis zambezensis* and, *Tilapia sparrmanii* to exist in the water bodies of SDM.

Even though South Africa has a diverse range of freshwater fish species, approximately 22% of those in SDM are threatened (Fish the Sea, 2020). This could be attributed to uncontrolled fish harvesting, water pollution, and predators, all of which endanger the long-term viability of inland fisheries as a source of income or a means of promoting the country's economy through tourism.

The Olifants River, on the other hand, is the largest tributary of the Limpopo River. The Olifants River has tributaries including the Wilge, Elands, Ga-Selati, Steelpoort, Blyde, Klaserie, and Timbavate rivers (Kotzé *et al.,* 2006). According to previous and current studies, it is the most polluted river in South Africa (Jooste *et al.,* 2014; Jooste *et al.,* 2015; Lebepe *et al.,* 2015; Huchzermeyer *et al.,* 2017; Sara *et al.,* 2018).

In SDM, the factors that cause river pollution include acid mine drainage and wastewater from treatment plants, fertilizer runoff, and changes in water regime within urban areas (LEDET, 2018). This has prompted a slew of studies into the quality of fish available from dams and rivers. For example, heavy metal contamination of fish from these water sources was found to be a concern by Addo-Bediako *et al.,* (2014a, 2014b); Jooste *et al.,* (2014); Jooste *et al.,* (2015); Lebepe *et al.,* (2015); Sara *et al.,* (2018). These findings, however, raise concerns about the health of the communities that consume the contaminated fish. Among the fish species are *Labeo rosae, Clarias gariepinus,* and *Hypophthalmicthys molitrix* (Jooste *et al.,* 2014; Jooste *et al.,* 2015; Sara *et al.,* 2018). Other fish species, on the other hand, respond differently to pollution [Environmental Protection Agency-United States (EPA-US), 2008; Fedorenkoza *et al.,* 2013]. Despite these challenges, SDM governance has made it a priority to clean the dams of pollutants for human consumption, which may improve the health of the dam's fish [Elias Motsoaledi Local Municipality Integrated Development Plan (EMLM IDP), 2019/2020]. To this end, the SDM provides a diverse range of fish species to achieve this goal; however, the frequency with which fish are consumed from bodies of water, as well as the type of fish consumed, should be monitored.

3.4. Mopani District Municipality (MDM)

3.4.1. Overview of Mopani District Municipality (MDM)

The name Mopani derives from the abundance of Mopani worms found in the district. The district is situated within the Great Limpopo Transfrontier Park (this park combines South Africa, Mozambique and Zimbabwe). Mozambique shares an international border with the municipality (in the north). Locally, the district is bordered by the Vhembe District Municipality through the Thulamela and Makhado Local Municipalities (in the south), and Mpumalanga Province through the Ehlanzeni District Municipality. Sekhukhune District Municipality borders this municipality to the west. The district also includes a section of the Kruger National Park, extending from the Olifants River to the

Tshingwedi camps, as well as the Lepelle and Tshingwedzi rivers. The district is divided into sixteen urban areas and 125 wards, with 354 villages [Mopani District Municipality Integrated Development Plan (MDM IDP), 2018]. The district's five local municipalities of MDM are Ba-Phalaborwa, Greater Tzaneen, Greater Letaba, Greater Giyani, and Maruleng.

The district receives the majority of its rain during the summer (85 percent). The average maximum temperature in the Kruger National Park ranges from 21 degrees Celsius in the mountains to 25 degrees Celsius in the dry Lowveld. Frost occurs infrequently in the district, making it an ideal environment for fish production (MDM IDP, 2018). Summers in the districts are warm, with minimum temperatures ranging from 16 to 22 degrees Celsius (with a mean of 19 degrees Celsius) and maximum temperatures ranging from 28 to 38 degrees Celsius (with a mean of 30 degrees Celsius), and the majority of precipitation falling in mid-summer. Winters are mild and dry with a minimum temperature of 5-11℃ (with a mean temperature of 8℃) and a maximum temperature of 19-26℃ (with a mean of 23℃). The municipality receives annual rainfall ranging from 400 to 900mm (Bodrick *et al.,* 2014).

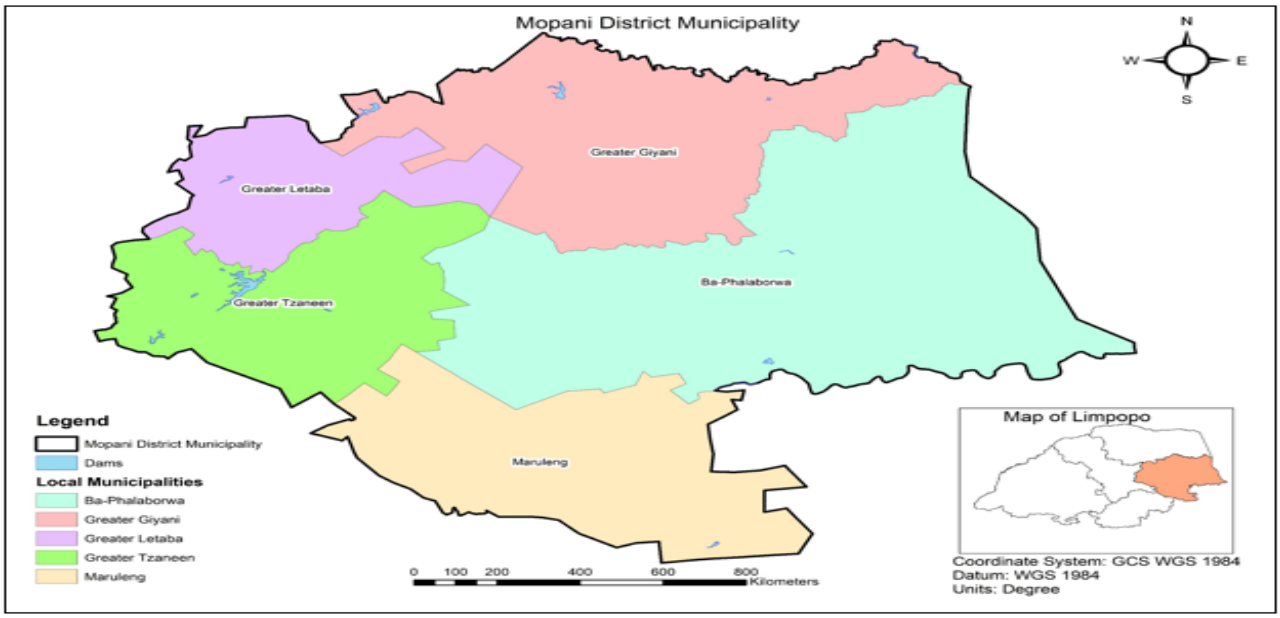

Figure 3.3: Mopani District Municipality

Source: Arc GIS 10.7.1

3.4.2. Main economic contributors in Vhembe District Municipality

a) Agriculture

Crop production for both subsistence and commercial uses takes place along the main rivers. In addition, the municipality produces maize and livestock (DRDLR, 2016). The Tzaneen and Letsitele portions of the Letaba watershed produce citrus, mangoes, and bananas. Families living near the Klein Letaba, Molototsi, and Nsami river catchments, on the other hand, raise cattle and goats. In addition, the district is notable for being South Africa's largest tomato producer (MDM IDP, 2019). Approximately 17% of the district's households are engaged in agricultural activities, according to statistics (Stats SA, 2016).

b) Mining

The district's mining activities are concentrated in the Ba-Phalaborwa Local Municipality. Copper, phosphate, and vermiculite are the most important minerals mined in the municipality, while magnatite, zirconium, nickel, uranium, iron, and gold are mined as by-products in smaller quantities (Ba-Phalaborwa Local Municipality IDP, 2019/2020). Palabora Mining Company, Floskor, and Stibium Mopani Mine are the municipality's major mining operators. In the 2018/2019 fiscal year, the mining sector in the district contributed more than 30% of Limpopo Province's GDP (Limpopo Provincial Treasury, 2018/2019).

c) Tourism

The Big Five, Rocky Mountains, indigenous forests, trout streams, and stunning waterfalls are just a few of the tourism attractions of the Mopani District Municipality. Modjadji Cycad Reserve and Forest, as well as the Big Hole, an open-cast mine, are among the municipality's highlights. Furthermore, the Kruger National Park, Timbavati Private Reserve, and the Blyde River Canyon are all tourist attractions close to the Maruleng Local Municipality. The district is home to major private game reserves and five-star luxury lodges such Thornbush and Kapama, Timbavati Private Game Reserve, Klaserie, Babule, and Oliphants. In addition, Hoedspruit is home to the world-famous Cheeter breeding park (a town in the district). As a result, there are chances to improve rural livelihoods through tourism in this industry. Accordingly, opportunities exist to improve rural livelihoods in this sector through tourism. Moreover, with the

number of dams and rivers, recreational fishing also serves as a tourism attraction opportunity (MDM IDP, 2019).

3.4.3. Potential of inland fisheries in the Mopani District Municipality

The municipality is crossed by perennial rivers such as the Ga-Selati, Makhutswi, Olifants, and Klaserie. The municipality's most notable dams include the Hlakula Dam, Tzaneen Dam, and Groot Letaba Dam, among others. Water is supplied to households in the municipality from a variety of sources. In the Maruleng Local Municipality, for example, approximately 2777 and 6924 households receive water from dams/pools/stagnant water and rivers/streams, respectively. These households have a direct opportunity to fish in these bodies of water if they have legal permission to do so. The *Micropterus dolomieu*, *Clarias gariepinus*, Kurper, Golden Carp, Southern Dwarf Minnow (*Opsaridium peringueyi*), African Tigerfish (*Hydrocynus vittatus)* and Rainbow Trout (*Oncorhynchus mykiss*) are among the fish species found in the municipality. Private resorts and parks such as Klaserie Caravan park, Hlakula Lake Resort and Fishing Safaris offer angling opportunities for tourists. The Ebenezer and Tzaneen Dams which irrigate the Letaba Valley, are known to be popular recreational sports in the district (MDM, 2014). To this end, there exists inland fisheries potential in this municipality. This can then contribute to household food security and household income.

3.5. Vhembe District Municipality (VDM)

3.5.1. Overview of Vhembe District Municipality (VDM)

The VDM is known for its cultural diversity and tradition. The district is located in the northern part of Limpopo Province and shares borders with Zimbabwe in the north, Mozambique in the east via Kruger National Park, and Botswana in the northwest. The Limpopo River separates the district from its international neighbours (MSA, 2020). The district encompasses 21 407 square kilometres of land and has 249 757 hectares of arable land. Thulamela, Makhado, Collins Chabane, and Musina are the four local municipalities that make up the district.

The VDM has a subtropical climate with mild, moist winters and wet, warm summers characterized by Lowveld (arid and semi-arid). The district receives 500mm of rain per year, with the majority of it falling between October and March. The annual

temperature ranges from a low of 10 degrees Celsius in the winter to a high of 40 degrees Celsius in the summer.

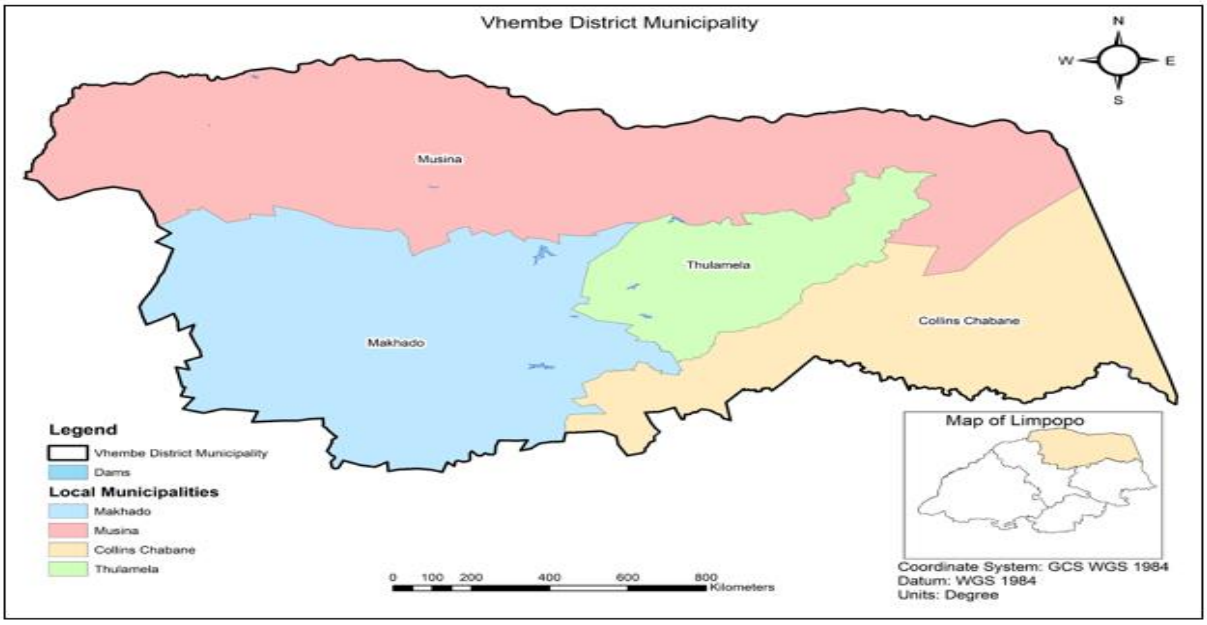

Figure 3.4: Map of Vhembe District Municipality

Source: Arc GIS 10.7.1

3.5.2. Main economic contributors in Vhembe District Municipality

a) Tourism

The district has multiple tourism sites such as Vhembe Biosphere Reserve, Nwanedi Conservancy, Western Soutpansberg tourism pan, Lake Fundudzi, Matshakatini, Breathing stone on Tswime mountain, Komatiland forests, Mutale gorge, Mukumbani waterfall, Tshatshingo Potholes, Mandadzi waterfall, The Big Tree, Dongodzivha Dam, Tshavhadinda cave, Tshipise Sagole, Aventura Tshipise, Route development, Transfrontier parks and, Mapungubwe Heritage site. Tourism plays an important part in the economy of the district. For example, the district is rich with various cultural and tourist activities and has more than seventy (70) heritage and cultures such as Archeological heritage sites, Golf tournaments, Cycle centres, Land and Legends Marathon, Two Countries Marathon, Powerade Krekmerant Race, 4x4 Challenge. Moreover, the district has thirty-eight (38) unique bird-watching sites which are in the Southpensburg Birding Route with about 540 different bird species [Vhembe District Municipality Integrated Development Plan (VDM IDP), 2019/2020]. Moreover, fishing

in the dams attracts tourists which in turn provides an opportunity for the locals to showcase their cultural crafts hence, generating household income.

b) Agriculture

The Vhembe District Municipality's arable land is located on the district's south-western and eastern borders. The municipality's agricultural sector is split between large-scale commercial farming and small-scale farming. Despite the fact that agriculture contributes to the district municipality's economy, problems such as high input costs and a shortage of ploughing machinery, among others, limit the sector's success. Citrus, avocados, macadamia, mango, banana, litchis, garlic, and maize may all be grown in the district's soil. In addition, goats, cattle, pigs, and poultry are raised by farmers in the district.

c) Mining

The district contains a number of mineral occurrences and zones (VDM IDP, 2017-2022). Tshipise Magnesite Field, coal fields (Mudimeli, Tshipise, Pafuri, Vele, Tshikondeni, and Mopane), Fumani gold mine, Musina copper, Schiel complex, Southpansberg group, Diamond in Madimbo corridor, copper in Makuya, Mangwele Diamond, Madonsi mine, and Tshimbupe iron are among them. Minerals such as iron, diamonds, granite, and marble make up the Beitbridge Complex (Limpopo Belt). The Vanetia Mine, which is located in the employs 63 percent of its workers from the district and neighbouring local towns like Blouberg (Vanetia Mine, 2013).

3.5.3. Potential of inland fisheries in the Vhembe District Municipality

Several studies undertaken in the Vhembe District Municipality have confirmed the occurrence of fishing. Tapela *et al.,* (2015); Phosa and Lethoko (2018); Sinthumule (2021) are examples of such investigations. In addition, Bassey *et al.,* (2012) looked into the gender dynamics and patriarchal system's influence on small-scale community fisheries management in Nandoni Dam. The study discovered gender inequalities in resource users, as fishing is typically thought to be a male activity, while women are active in post-harvesting activities. The Nandoni Dam is used for a variety of purposes, including water supply for nearby local communities, fishing, washing clothes, agriculture, irrigation, bathing, and watering animals, according to Britz *et al.,* (2015) and Tapela *et al.,* (2015).

Fish species such as *Schilbe intermedius*, *Labeobarbus marequensis* and *Oreochromis mossambicus* are among some of the fish species found in Vhembe District Municipality (Water Research Commission, 2013). It is reported that there are currently 18 aquaculture projects in the district (VDM IDP, 2017-2022). Therefore, a need arises to investigate the current fisheries activities practised by the households in VDM. The findings may reveal information about the district's inland fisheries' long-term viability for food security and revenue creation, as well as how alternative initiatives, such as fish farming, can help alleviate poverty, particularly for households that rely on fisheries for a living. Furthermore, proper management of inland fisheries resources may prevent pollution from dams through proper enforcement, while also taking into account the poor households who rely on these resources.

3.6. Summary of study area

Agriculture, tourism, and mining are clearly the economic drivers of the Sekhukhune, Vhembe, and Mopani District Municipalities, as evidenced by their economic backgrounds. Furthermore, because these districts are predominantly rural, most active inland water resources (such as dams, streams, and rivers), as well as numerous fish species, provide opportunities for households to participate in inland fisheries for food security and income generation. Furthermore, the climate, the presence of huge dams, and present fishing activities all play a role in the decision to gather data in these three district municipalities.

Although studies show that inland fishing occurs in these districts, it is not known how this sector contributes to livelihoods. Similarly, the existence of fisheries within these districts suggests that the inland fisheries sector could thrive with the coexistence of agriculture, mining, and tourism. Finally, because the districts are diverse in terms of fish species recognized in the market, there is a need for these fish species to be protected by local and government authorities in order to maintain sustainability and control harvest if households are to venture into commercialisation.

3.7. Research methodology and analytical procedures

3.7.1. Research design

The study used cross-sectional data to capture information regarding the economic assessment of inland fisheries towards income generation and food security in

Limpopo Province. Therefore, data were collected to capture information from the households.

3.7.1.1. Methods and research instruments

The study is quantitative research in nature. According to Apuke (2017), quantitative research involves the utilisation and analysis of numerical data using specific statistical techniques to answer questions like who, how much, what, where, when, how many and how. It also describes the methods of explaining an issue or phenomenon through gathering data in numerical forms. Primary data was collected using structured questionnaires. The data was collected from both fishing and non-fishing households in the study area. Therefore, the collected data was for the following purposes:

a. Socio-economic information of participants, different roles played by households and their function along the inland fisheries value chain
b. Contribution of inland fisheries to household income
c. Contribution of inland fisheries to household food security

3.7.1.2. Sampling frame

Data was collected from both households involved in inland fisheries and those not involved. For example, to obtain food security information, data was collected from both households. However, to determine the contribution of inland fisheries to household income, data was only collected from households involved in inland fisheries. Snowball and convenient sampling techniques were used to capture the role players' information.

a) Sampling procedure for households' participants

Primary data was collected through a structured questionnaire via face-to-face interviews and telephone communication. Multistage sampling was employed to gather data from respondents. As an extension of cluster sampling, multistage entails two or more stages of random sampling that consist of selecting a cluster and randomly selecting a specified number of units from each selected cluster (Singh and Mangat, 1996; Sedgwick, 2015). In this study, multistage sampling was performed such that the Limpopo Province was first divided into its five districts (namely Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg) and only three districts were chosen for the study (stage 1) [Vhembe, Mopani, and Sekhukhune].

Using information obtained from Stats SA (2016), it was found that Sekhukhune District has 290 527 households under four local municipalities, Mopani District has 338 427 households within its five local municipalities while Vhembe District has 382 357 households under four local municipalities. The next stage involved dividing the three districts into 13 local municipalities (stage 2). The third stage involved the selection of villages from the 13 local municipalities where households were selected based on sampling proportionate to size. Stats SA (2014); World Bank (2018) attest that these three districts where the poorest in Limpopo Province and consist of large dams such as Nandoni, Middle Letaba and Flag-Boshielo Dams within the province.

Table 3.1: The total number of households in SDM, MDM and VDM

District Municipality	Local Municipality	Households
Sekhukhune (290527)	Elias Motsoaledi	66359
	Ephraim Mogale	33936
	Fetakgomo Tubatse	125361
	Makhuduthamaga	64871
Mopani (338427)	Ba-Phalaborwa	49100
	Greater Giyani	70477
	Greater Letaba	67067
	Greater Tzaneen	122776
	Maruleng	29007
Vhembe (382357)	Collins Chabane	91936
	Makhado	116371
	Musina	43730
	Thulamela	130320
Total		1011311

Source: Stats SA (2016)

Yamane's (1967) formula was used to calculate the minimum sample size.

$$n = \frac{N}{1+Ne^2}$$

Where: n = sample size, N=total population, e^2=margin of error (0.05). This gives a total sample of 400 households. Probability proportionate to size was used to identify the number of households to be interviewed. These give a total of 151 households in

Vhembe District, 134 in Mopani District and 115 in Sekhukhune District. From the sample size, a proportional random sampling technique was therefore employed to select households to participate in the study under selected local municipality as shown in Table 3.2 below.

Table 3.2. Distribution of sample size concerning the selected local municipality

Dist.	Local municipality	Sample size	Total
SDM	Fetakgomo Tubatse	59	115
	Makhudumathamaga	34	
	Ephraim Mogale	22	
MDM	Greater Tzaneen	60	134
	Greater Letaba	58	
	Greater Giyani	16	
VDM	Thulamela	70	151
	Musina	25	
	Makhado	56	

Source: Research survey (2021)

Table 3.2 presents the distribution of sample size concerning selected local municipalities in the Limpopo Province. These municipalities include Fetakgomo Tubatse, Makhuduthamaga and Ephraim Mogale Local Municipalities which are in the Sekhukhune District. Greater Tzaneen, Greater Letaba and Greater Giyani Local Municipalities in the Mopani District. Where else, Thulamela, Musina and Makhado Local municipalities are in the Vhembe District. These local municipalities were chosen because of the fishing activities currently taking place at the dams and rivers. Data were collected from fishers and households that consume fish. Moreover, data for the households that do not consume fish was also captured.

b) Sampling procedure for the selection of inland fisheries role players

The study employed snowball and convenient sampling to identify different roles played by households within the inland fisheries value chain in the Limpopo Province. These households indicated that they play the role of input supplier, fisher, trader, processor, and consumer. Normally, some fish traders are found at busy streets or

street junctions. For the households who are not involved in the actual fishing, they would call the fisher when they want to buy fish or travel to the market.

3.8. Enumerator selection and training

A total of five (5) enumerators were selected to assist with data collection. These enumerators were chosen based on their familiarity with fishing areas in the chosen district municipalities. Moreover, all the enumerators had at least Grade 12 matric certificates and were fluent in the local spoken language. Two enumerators from the Sekhukhune District municipality were fluent in Sepedi as it is the dominant language spoken. Another two from the Vhembe district fluent in Tshivhenda were also selected. In Mopani, one enumerator was fluent in Tshitsonga, Sepedi and Khilobedu languages to assist with data collection.

Due to Coronavirus disease 19 (Covid-19) restrictions in South Africa, training started online because of the movement and contact restrictions that were imposed by the government. Covid-19 is an exceedingly transmittable and pathogenic viral infection that is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-Cov-2) (Shereen *et al.,* 2020). This virus has currently spread around the world limiting contact with people. However, the Covid-19 lockdown levels differ (level 1-5). Hence, the South African government imposed a 21-day lockdown level 5 on 26 March 2020. The lockdown was then downgraded to level 4 on the 1st to 30th May 2020, then to level 3 on the first of June 2020. The country then moved to levels 2 and 1 on the 18th August 2020 and 20 September 2020 respectively. Data was collected during level 2 and 1, however, the country then moved back to level 3 (29 December 2020) which restricted access to fishing areas such as dams and some households become reserved in welcoming enumerators in their homes. When restrictions were lifted, the team resumed data collection. Covid-19 regulations were followed during interviews. A pre-test was done with 20 questionnaires and adjustments were made based on the new information obtained. The adjusted questionnaire was then shared and discussed by the team. The enumerators were trained on how to approach and communicate with the respondents.

3.9. Analytical techniques

This section presents the analytical techniques used in the study.

3.9.1. Descriptive statistics

In this study, descriptive statistics were employed to profile the socio-economic characteristics of rural households and describe different roles played by households and their function along the inland fisheries value chain. As a branch of statistics employed to summarise and organise small or large amounts of data, descriptive statistics provide summarised data by giving details about the population from which the sample was drawn. Descriptive statistics consists of methods and procedures such as tables, graphs, frequencies, a measure of variability (such as the standard deviation) and measures of central tendency (such as the mean, mode and median) [Sheskin, 2000; Larson, 2006; Holcomb, 2017]. These methods were used in this study.

3.9.2. Pearson Chi-square and Pearson's Product Moment Correlation (r)

To check the relationship between socio-economic characteristics of role players and their function along the inland fisheries value chain a Pearson Chi-square and Pearson's Product Moment Correlation test were employed. The Pearson Chi-square of independence is used to test the relationship between two categorical variables (Ugoni and Walker, 1995).

The Pearson's Product Moment Correlation (r) is used to demonstrate the relationship between two or more quantitative variables (Gogtay and Thatte, 2017). To measure the strength or the degree of a linear association between variables and their direction, correlation coefficients are used. The correlation coefficients are applied to measure the relationship between the variables (Obilor and Amadi, 2018).

The Pearson correlation coefficient values range between -1.00 and 1.00 and it is categorised into three: positive correlation, negative correlation and no correlation. A value of 0 indicates no correlation which means other variables do not tend to increase or decrease. If the sign of the correlation coefficient is positive (meaning the other variable tends to also increase), then it is regarded as a positive correlation. If the sign of the correlation coefficient is negative, then it is regarded as a negative correlation which means that the other variable tends to also decrease (Sedgwick, 2012). For

example, a correlation coefficient that is lower than ±0.40 is considered to be low, correlation coefficients between ±0.40 and ±0.60 are regarded as moderate correlation. However, variables correlating greater than ±0.60 are said to be highly correlated (Obilor and Amadi, 2018).

Several studies have used the Pearson correlation to test relationship between variables. For example, Davadawson *et al.,* (2015) employed the Pearson correlation to determine the relationship between socio-economic demographics and the amount of fish eaten in Eastern community, Sri Lanka; the association between consumer preference/attitude and the demographics of fish farmers in Kingdom of Saudi Arabia was tested by Khan *et al.,* (2016). Other authors tested the relationship between buying fish from the inland and the intention of consumers (Jayasinghe *et al.,* 2019). Therefore, this study adopted the Pearson correlation in order to test the relationship between the socio-economic characteristics of role players and their function along the inland fisheries value chain.

The formula of the Pearson's Product Moment Correlation for the coefficient is given by (LeBlanc and Cox, 2017):

$$r = \frac{cov\ (x,y)}{s(x) \times s(y)}$$

Where: r denotes the Pearson's Product Moment Correlation

$cov\ (x, y)$ is the covariance between scores x and y

$s(x)\ \times s(y)$ represents the standard deviation of the scores in x and y

3.9.3. Income share

Objective two was to determine the contribution of inland fisheries to household income. The study used the mean income share to estimate the shares of income obtained from individual households by finding the share of each income source in the total household income of each household. In this study, the mean share of income determines how much income does inland fisheries contribute to the total household income. The general mean of income shares formula is given as (Agyeman *et al.* 2014):

$$MS_i = \frac{\sum_{h=1}^{n} {}^{y_{ith}}/_{Y_h}}{n} \quad (1)$$

Where: i is the income source, y is the income from particular activity (Rands, R), Y= total income (Rands, R), h is the household, n is the number of households. The sum of Total Income of Households (THI) is given by:

$$THI = \sum_{j=1}^{n} Y_j$$

Where: THI is Total Household Income (which is income coming from all sources j), where $j = 1,2,3, \ldots, k$ (sources of income from fishing and non-fishing income). Therefore, equation (1) is applied in this study as:

$$THI = \sum_{j=1}^{14} Y_j \quad (2)$$

Where: THI is Total Household Income, which is income coming from all sources j, where $j = 1,2,3, \ldots,14$ (sources of income from fishing and non-fishing income).

The mean Share of Fishing Income (SFI) is given as:

$$SFI = \sum \left[\sum \frac{LFP}{n} + \sum \frac{SFP}{n} + \sum \frac{RFI}{n} + \sum \frac{MFD}{n} + \sum \frac{SPF}{n} + \sum \frac{SRF}{n} + \sum \frac{OFI}{n} \right] \quad (3)$$

Where: SFI is Share of Fishing Income, LFP is income from loaning fish inputs, SFP is income from selling fishing inputs, RFI is income from repairing fishing inputs, MFD is income from fish marketing and distribution, SPF is income from selling processed fish, SRF is income from selling raw fish, OFI is income from other fishing sources and, n is a number of households engaged in fishing activities.

The mean Share Non-fish Income (SNFI) is given by:

$$SNFI = \sum \left[\sum \frac{IFCP}{n} + \sum \frac{IFLP}{n} + \sum \frac{SGS}{n} + \sum \frac{RMT}{n} + \sum \frac{SLE}{n} + \sum \frac{WEG}{n} + \sum \frac{OTS}{n} \right] \quad (4)$$

Where: $SNFI$ is Share of Non-Fishing Income, $IFCP$ is income from crop production, $IFLP$ is income from livestock production, SGS is income from social grants, RMT is income from remittances, SLE is income from self-employment, WEG is income from wage-earnings and OTS is other sources of income, n is a number of households.

To measure the level of income diversity of fishing households, the study used the Simpson Index Diversity (SID). The general formula of SID is given as:

$$SID = 1 - \sum_{i=1}^{n} P_i^2 \quad (5)$$

Where: SID is the Simpsons Index Diversity, n is the number of income sources, P_i is the proportion of income coming from the source i. In this study, the SID model is expressed as follows:

$$SID = 1 - \sum_{i=1}^{14} \left[\left(\frac{LFP}{THI}\right)^2 + \left(\frac{SFP}{THI}\right)^2 + \left(\frac{RFI}{THI}\right)^2 + \left(\frac{MFD}{THI}\right)^2 + \left(\frac{SPF}{THI}\right)^2 + \left(\frac{SRF}{THI}\right)^2 + \left(\frac{OFI}{THI}\right)^2 + \left(\frac{IFCP}{THI}\right)^2 + \left(\frac{IFLP}{THI}\right)^2 + \left(\frac{SGS}{THI}\right)^2 + \left(\frac{RMT}{THI}\right)^2 + \left(\frac{SLE}{THI}\right)^2 + \left(\frac{WEG}{THI}\right)^2 + \left(\frac{OTS}{THI}\right)^2\right] \quad (6)$$

The value of SID ranges between 0 and 1. If a household has only one source of income, $P_i = 1$, the $SID = 0$. As the number of income sources increase, the shares of P_i decreases. The sum of the squared shares also decreases, thus the SID approaches 1. If there are k sources of income, the value of SID will fall between 0 and $1 - \frac{1}{k}$ (Sultana *et al.,* 2015). Therefore, a SID of 0 indicates no diversification and as the value moves closer to 1, this shows extreme diversification of household income. Based on the values of the SID, the level of diversification is defined in Table 3.3.

Table 3.3: Simpson Income Diversity index decision conditions

Level of diversification	SID values
No diversification	≤0.01
Low level of diversification	0.01-0.25
Medium level of diversification	0.26-0.50
High level of diversification	0.51-0.75
Very high level of diversification	>0.75

Source: Ahmed *et al.,* (2018)

3.9.4. Multiple Linear Regression model

The Multiple Linear Regression model (MLRM) was used to analyse factors influencing the income of fishing households. The MLRM is a model that shows the relationship between a dependent variable and multiple independent variables (Greene, 2002). The MLRM assumes that there is no linear relationship between the dependent variable and the independent variable, and the residuals are normally

distributed. Moreover, the MLRM assumes that the independent variables are not highly correlated with each other. This assumption is tested using the Variance Inflation Factor (VIF). Several authors used the MLRM to analyse factors influencing household income (Zhang, 2015; Mesra, 2018). Greene (2002) provides the generic form of the MLRM as:

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k + \varepsilon$$

Where Y is the dependent variable (household income of fishers), β_0 is the intercept, $\beta_1, \ldots, \beta_k$ are the coefficients of the estimated parameters, $X_1, \ldots, X_n$ are the independent variables and ε is the error term.

Table 3.4: Description of variables for specifying factors influencing the household income of fishers using Multiple Linear Regression

Variables		Description	Unit of measure
Dependent variable			
THIN (Y)	Household income	The total household income of fishers	Rands
Independent variables			
AGE (X_1)	Age	Age of household head	Years
GEND (X_2)	Gender	1 Male, 0 otherwise	Dummy
NHHS (X_3)	Household size	Number of people in the household	Number
MRS (X_4)	Marital status of household head	1 if married, 0 otherwise	Dummy
HEDL (X_5)	Level of Education	1 if the respondent has formal education, 0 otherwise	Dummy
ACRE (X_6)	Access to credit	1 if the household has access to credit, 0 otherwise	Dummy
DIST (X_7)	Distance	Distance to the market	Kilometres

NYRF (X_8)	Number of years fishing	Fishing experience in years	Years
DISM (X_9)	Fishing distance	Distance to fishing area/spot	Kilometres
RFFG (X_{10})	Reason for fishing	1 if consumption, 2 if business, 3 if hobby	Categorical
NYRF (X_{11})	Number of years fishing	Fishing experience in years	Years
DISM (X_{12})	Fishing distance	Distance to fishing area	Kilometres
TIFS (X_{13})	Type of inland fisheries	1 if small-scale, 2 if subsistence, 3 if recreational	Categorical
AVPF (X_{14})	Average selling price	Average selling price of fish per gram	Rands
AQFS (X_{15})	Average quantity of fish	Average quantity of fish sold per year per kg	Continuous

Source: Own compilation (2021)

3.9.5. Binary Logistic Regression model

The binary logistic regression belongs to the family of logistic regression wherein the dependent variable is a binary. The model works like the linear regression model but with a binomial response expressed as a probability that falls between 0 and 1 (Horowitz and Savin, 2001). Since the logistic is dichotomous, it is appropriate to be used in analysing the determinants of households' dietary diversity because it has the probability range of 0 and 1 hence linear models are not recommended for this analysis. Several studies have used the binary logistic model to determine household dietary diversity (Taruvinga *et al.,* 2013; Cheteni *et al.,* 2020).

In this study, the High dietary diversity (HDD) and Low dietary diversity (LDD) were employed as dependent variables and coded as 1 and 0 respectively. The general binary logistic regression is given by:

$$log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n + \alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: P is the probability of households having high dietary diversity (HDD), $1 - P_1$ is the probability of the household having a low dietary diversity (LDD), log is the natural logarithm, β_0 is the intercept, $\beta_1, \ldots, \beta_n$ are the coefficients of the estimated parameters, $X_1, \ldots, X_n$ are the independent variables and α is the error term.

Table 3.5: Description of variables for specifying determinants of rural households' dietary diversity using Binary Logistic model

Variables		Description	Unit of measure
Dependent variable			
HDD (Y)	Household dietary diversity	0 if the household has low dietary diversity, 1 if the household has high dietary diversity	Dummy
Independent variables			
AGE (X_1)	Age	Age of household head	Years
GEND (X_2)	Gender	1 Male, 0 otherwise	Dummy
NHHS (X_3)	Household size	Number of people in the household	Number
MRS (X_4)	Marital status of household head	1 if married, 0 otherwise	Dummy
SOIN (X_5)	Source of income	1 if income is from fishing sources, 0 otherwise	Dummy
THIN (X_6)	Household income	Total household income per month	Rands
HEDL (X_7)	Level of Education	1 if the respondent has formal education, 0 otherwise	Dummy
MACE (X_8)	Market access	1 if the household has access to market, 0 otherwise	Dummy
ACRE (X_9)	Access to credit	1 if the household has access to credit, 0 otherwise	Dummy

DIST (X_{10})	Distance	Distance to the market	Kilometres
AGRP (X_{11})	Agricultural production	1 if households practice agriculture, 0 otherwise	Dummy
TIFS (X_{12})	Type inland fisheries	1 if small-scale, 2 if subsistence, 3 if recreational	Categorical
AVPF (X_{13})	Average selling price	Average selling price of fish per gram	Rands
AQFS (X_{14})	Average quantity of fish	Average quantity of fish sold per year per kg	Continuous
FLAB (X_{15})	Fish labours	1 if household has fishing labours, 0 otherwise	Dummy

Source: Own compilation (2021)

3.9.6. Multinomial Logistic Regression Model

According to Starkweather and Moske (2011); El-Habin (2012), multinomial logistic regression is used to predict the categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables. As stated by Monyai *et al.,* (2016), the multinomial logistic regression provides the pseudo-R^2 as the correlation measure which estimates the extent of the strength of the relationship between the dependent and the independent variables. The pseudo-R^2 also plays a role in assessing the accuracy of the model by comparing the predicted values of the model to the observed values.

In this study, the dependent variable is categorised as 0=food secure; 1=mildly food insecure; 2=moderately food insecure and 3= severely food insecure. Therefore, the study adopted a Multinomial Logistic regression model to determine factors affecting the food security status of fishing and non-fishing households. The model can be expressed as (Greene, 2002):

$$Pr(Y_i = j) = \frac{exp^{(\beta_j x_i)}}{\sum_{j=o}^{j} exp\left(\beta'_j x_i\right)} \; for\; j = 0,1,2,3$$

Where: $Pr(Y_i = j)$ = probability of household's food security status (0=food secure; 1=mildly food insecure; 2=moderately food insecure and 3= severely food insecure), j = number of household's choice categories in the choice set, X_i = vector of explanatory variables, β_i = parameters to be estimated.

The estimated equation provides a set of probabilities for the $j + 1$ choice restricted for a decision-maker with characteristics x_i. A convenient normalization that solves $\beta_{0=}0$ should be applied to remove an interdependency of the model. Therefore, the probability that household i^{th} choose the alternative j^{th} can then be derived from the general form as follows:

$$Pr\left(Y_i = \frac{j}{x_i}\right) = \frac{exp^{\left(\beta'_j x_i\right)}}{\sum_{j=o}^{j} exp\ \left(\beta'_j x_i\right)} for\ j\ =\ 0, 2, \ldots, j, \beta_0 =\ 0$$

However, the coefficients of Multinomial Regression are difficult to interpret. Attempting to associate the β_j with the jth outcome will be misleading. Marginal effects are then used to interpret the effects of the explanatory variables on the probabilities. Marginal effects measure the expected change in the probability of a specific outcome being made concerning a unit change in an explanatory variable (Monyai *et al.,* 2016). Taking marginal effects into consideration, the model is then and is derived as:

$$\partial_{i=} \frac{\partial P_j}{\partial X_j} = P_j\left[\beta_j - \sum_{j=1}^{j} P_j\ \beta_j\right] = P_j\left[\beta_j - \bar{\beta}\right]$$

Table 3.6: Description of variables for specifying the effects of inland fisheries on household food security status using Multinomial Logistic regression

Variables		Description	Unit of measure
Dependent variable			
FSSH (Y)	Food security status of households	0=Food secure,1=mildly, 2=moderately,3=severely food insecure	Categorical
Independent variables			
AGE (X_1)	Age	Age of household head	Years

GEND (X_2)	Gender	1 Male, 0 otherwise	Dummy
NHHS (X_3)	Household size	Number of people in the household	Number
THIN (X_4)	Household income	Total household income per month	Rands
MRS (X_5)	Marital status of household head	1 if married, 0 otherwise	Dummy
HEDL (X_6)	Level of education	1 if the respondent has formal education, 0 otherwise	Dummy
DIST (X_7)	Distance	Distance to the market	Kilometres
RFFG (X_8)	Reason for fishing	1 if consumption, 2 if business, 3 if hobby	Dummy
SOIN (X_9)	Source of income	1 If income is from fishing activities, 0 otherwise	Dummy
AGRP (X_{10})	Agricultural production	1 if households practice agriculture, 0 otherwise	Categorical
DISM (X_{11})	Fishing distance	Distance to fishing area/spot	Kilometres

Source: Own compilation (2021)

3.10. Food security index estimates

3.10.1. Household Dietary Diversity Score (HDDS)

Household Dietary Diversity Score (HDDS) is a qualitative measure of food consumption that reflects the access of households to various foods (Kennedy *et al.,* 2013). The HDDS applies a reference period of usually the previous 24-hours recall which precisely consist of recalling, describing and quantifying the intake of food and beverages consumed either by the household or individual in the previous 24 hours (Castell *et al.,* 2015). The HDDS works by checking the number of food groups consumed over a given reference period. The HDDS assessment helps in terms of measuring the dietary intake of nutrients contained in various foods and the quantity of food consumed by the households. The HDDS indicates a better quality of diets by

listing a set of 12 food groups and it is recommended as a proxy to measure the social and the economic access of food by household (Swindale and Bilinsky, 2006).

The HDD includes a set of questions that should be directed to the person responsible for preparing meals within the household. If the person is not available, another adult who ate the food can be able to answer the questions. The questions refer to the entire household and not an individual. In addition, food consumed outside the household and were not prepared in the home was not considered however, food bought or gathered outside the household but consumed at home is considered. The respondent is asked a series of yes or no questions. Since this study focuses on the household per se, the HDDS questions are directed to the person who is responsible for food preparation the previous night and refers to the consumption of food not on an individual level but to the entire household. However, food that was bought and eaten outside the household was not considered.

The Food and Nutrition Technical Assistance (FANTA) has designed a set of various food groups that households consume. Therefore, the HDDS indicates a better quality of nutrients by listing a set of 12 food groups. For the study, households were asked based on the food groups they have consumed over the past seven days and the dietary diversity of households participating in inland fisheries and those not participating was considered. This was done to check the dietary diversity differences among these households. These food groups are presented in Table 3.7.

Table 3.7: Household Dietary Diversity food groups

Food Group		Points
A	Any bread, rice, noodles, biscuits, or any other foods made from millet, sorghum, maize, rice, wheat or any other locally available grain.	1
B	Any potatoes, yams, manioc, cassava or any other foods made from roots or tubers.	1
C	Any vegetables.	1
D	Any fruits.	1
E	Any beef, pork, lamb, goat, rabbit, wild game, chicken, duck, other birds, liver-kidney, heart or other organ meats.	1

F	Any eggs	1
G	Any fresh, dried fish or shellfish	1
H	Any foods made from beans, peas, lentils or nuts	1
I	Any cheese, yoghurt, milk or other milk products	1
J	Any foods made with oil, fat or butter	1
K	Any sugar or honey	1
L	Any other foods such as condiments, coffee or tea	1

Source: Taruvinga *et al.,* (2013)

To calculate the scores, the HDDS is first calculated for each household were its value will range from 0-12 (Swindale and Bilinsky, 2006). This is given by adding the total number of food groups consumed by members of the households over a given reference period. Each food group is given a score of 1 if the answer is yes to each food group the household consumed in the past seven days and 0 if the answer is no, which gives a total of 12 food groups. Therefore:

$$HDDS_{0-12} = \mathrm{SUM}(\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{D}, \mathrm{E}, \mathrm{F}, \mathrm{G}, \mathrm{H}, \mathrm{I}, \mathrm{J}, \mathrm{K}, \mathrm{L})$$

Where: $HDDS_{0-12}$ represent the Household Dietary Diversity Score, $\mathrm{A\ to\ L}$ is the different food groups where the values are given 1 (if consumed) or 0 (if not consumed). Thus, a single point was given to each food group consumed by the household over a given reference period given a positive response. Following Mantsho (2018), two mutually exclusive levels have been used to group the scores, is High Dietary Diversity (HDD) and Low Dietary Diversity (LDD). A Dietary Diversity of 0-5 reflects LDD, where else a score of 6-12 indicates HDD. Secondly, the average Household Dietary Diversity Score is then calculated for the population sampled. This is given by (Swindale and Bilinsky, 2006):

$$Average\ HDDS = \frac{Sum\ (HDDS)}{Total\ number\ of\ households}$$

3.10.2. Household Food Insecurity Access Scale (HFIAS)

Household Food Insecurity Access Scale (HFIAS) measures access as a pillar of food security. The HFIAS is an initiative from the Food and Nutrition Technical Assistance (FANTA) which identified a set of Household Food Insecurity Access Scale Generic

questions that are used when distinguishing food-secure from food-insecure households looking at whether they have been able to access food in the previous 30 days (Coates *et al.,* 2007). Additionally, the HFIAS is composed of nine occurrence questions combined with a set of nine frequency questions. The measured results are then assigned categorical descriptions or given a numerical value of 0-27 with higher numbers representing a greater level of food insecurity.

Like the HDDS, the response for the HFIAS, is ideally the household head or the person in charge of food preparation. The information provided by the HFIAS is used basically to measure the occurrence of food insecurity at the household level and to monitor and evaluate the food insecurity changes of the household (Coates *et al.,* 2007).

Table 3.8: Household Food Insecurity Access Scale Generic questions

Question number	Occurrence question	Code*
1	In the past four weeks, did you worry that your household would not have enough food?	
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	
3	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	
4	In the past four weeks, did you or any household member have to eat some foods that you did not want to eat because of a lack of resources to obtain other types of food?	
5	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	
6	In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	

7	In the past four weeks, was there ever no food to eat of any kind in your household because of a lack of resources to get food?	
8	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	
9	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	

*The code is represented by 1 =rarely (once or twice in the past 4 weeks), 2 =sometimes (three to ten times in the past 4 weeks), 3=often (more than 10 times in the past 4 weeks).

Source: Coates *et al.,* (2007)

Each of the nine questions in the HFIAS is asked based on a recall period of four weeks which is equivalent to 30 days. The respondent is first asked an occurrence question which simply asks whether the condition in the question happened at all in the past four weeks. If the respondent answers 'yes' to an occurrence question, a frequency of occurrence question is asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks. However, if the respondent reports that they have not experienced the conditions that are described in the occurrence question in the previous 30 days, the frequency of occurrence questions is skipped. If the household responds rarely (once or twice) or sometimes (three to ten times) to an occurrence question, these are coded with a response code of 1 and 2 respectively. The maximum score for a household is 27 which means that the household responded with often to all nine frequencies of occurrence and is coded with a response code of 3. The minimum score is 0 which means the household responded with 'no' to all occurrence questions (Coates *et al.,* 2007). A HFIAS score variable is calculated for each household by adding the codes for each frequency of occurrence question.

After obtaining the scores, the Household Food Insecurity Access Prevalence (HFIAP) is used as a status indicator that categorises households into four levels of food insecurity (access). For example, households are categorised into food secure, mild,

moderately and severely food insecure. The more the household responds positively to more food insecurity conditions and either experience those conditions more frequently, the more they fall into the category of severe food insecurity (Coates *et al.* 2007). Following Coates *et al.,* (2007) and Mango *et al.,* (2014), the HFIAS is given by:

$$HFIAS\ (0-27) = Q_{1a}F_1 + Q_{2a}F_2 + Q_{a3}F_3 + Q_{a4}F_4 + Q_{5a}F_5 + Q_{6a}F_6 + Q_{7a}F_7 + Q_{8a}F_8 + Q_{9a}F_9$$

Where Q is the occurrence question and F represents the frequency of occurrence $HFIAS$ is the household food insecurity access scale and 0-27 is the score of $HFIAS$. According to Chakona and Shackleton (2018), the possible scores of HFIAS ranging from 0-27 are grouped in two-four where 0-1 categorises households as food secure. A score of 2-7, 8-11 and greater than 11 is categorised as mildly, moderately and severely food insecure households respectively. The average score is given by Coates *et al.,* (2007) as:

$$Average\ HFIAS\ Score = \frac{Sum\ of\ HFIAS\ in\ the\ sample}{Total\ number\ of\ scores\ (i.e.households) in\ the\ sample}$$

3.11. Summary of analytical techniques adopted in the study

Summary of the analytical techniques used to achieve the objectives of the study are presented in Table 3.9.

Table 3.9. Objectives, hypotheses and analytical techniques were used to address the objectives of the study.

Objectives	Hypotheses	Model
i. To identify and describe socio-economic characteristics of households and their different roles and functions played along the inland fisheries value chain in the Limpopo Province.	Rural households only play the role of fishers and consumers in the inland fisheries value chain	Descriptive statistics Pearson Chi-square Pearson's Product Moment Correlation (r)

ii. To determine the contribution of inland fisheries to household income in the study area.	Inland fisheries do not significantly contribute to household income	Income share Simpson Income Diversity index Multiple Linear Regression model
iii. To determine the contribution of inland fisheries to household food security status in the study area.	Inland fisheries do not significantly contribute to household food security	Household Dietary Diversity Score Binary Logistic Regression model Household Food Insecurity Access Scale Multinomial Logistic Regression model

Source: Own compilation (2021)

CHAPTER FOUR

DESCRIPTIVE STATISTICS, EMPIRICAL FINDINGS AND DISCUSSIONS

4.0. Introduction

The results presented in this chapter are for all the objectives of the study. The first objective was to identify and describe socio-economic characteristics of households and the different roles and functions played along the inland fisheries value chain in the Limpopo Province. The second objective was to determine the contribution of inland fisheries to household income in the study area. Finally, objective three was to determine the contribution of inland fisheries to household food security. Selected socioeconomic characteristics of households in the study area are discussed in this chapter. The results were generated using descriptive statistics and Pearson's Chi-square. SPSS (Statistical Package for Social Science) Version 27 and STATA version 15 were used to generate the results.

4.1. Socio-economic characteristics of households in SDM, MDM and VDM

Table 4.1 shows continuous variables linked to socioeconomic features of households in the Sekhukhune District Municipality (SDM), Mopani District Municipality (MDM), and Vhembe District Municipality (VDM). It contains socio-economic characteristics of inland fisheries households, non-fisheries households, and the complete sampled households in the study area. The total sample size in SDM is 115, with 72 people active in fisheries and 43 non-fishing households. MDM and VDM have sample sizes of 134 and 151, respectively. The number of households engaging in inland fisheries in MDM and VDM is 59 and 62, respectively. Furthermore, 75 households are not active in inland fisheries for MDM and 89 for VDM.

The average age of all sampled households in SDM is 48, while the average age in MDM is 47. In VDM, the average age is 46. This indicates that the majority of responders in all three districts are still in their working years. In SDM, the household head has a maximum age of 94 years, a minimum age of 26 years, and a standard deviation of 14.5 years. The MDM has a maximum age of 82, a minimum age of 19, and a standard deviation of 14.71. The VDM on the other hand, has a maximum age of 89 years, a minimum age of 22, and a standard deviation of 14.23. These are the results for all of the households that were sampled.

Table 4.1: Descriptive results of continuous variables for fishing, non-fishing and entire sampled households in SDM, MDM and VDM

SDM												
Variables	Minimum			Maximum			Mean			Standard Deviation		
	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH
Age	26	29	26	76	94	94	47	49	48	13.54	16.17	14.53
Number of household members	1	2	1	13	13	5	6	5	5	2.61	2.28	2.52
Total household income	1600.00	1350.00	1350.00	30400.0	20000.00	30400.00	9015.9	6348.49	8018.52	7392.98	4912.25	6679.11
Distance to market	.50	0.70	0.50	3.5	3	3.50	1.42	1.34	1.39	0.63	0.66	0.64
Number of years fishing	2	-	-	32	-	-	14	-	-	7.69	-	-
Distance to fishing area	0.30	-	-	11.00	-	-	2.5	-	-	3.31	-	-
Ave. price of fish	.00	-	-	45.00	-	-	10.26	-	-	13.07	-	-

Ave. quantity of fish sold	.00	-	-	14000	-	-	178	-	-	282.56	-	-
MDM												
Variables	Minimum			Maximum			Mean			Standard Deviation		
	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH
Age	19	24	19	82	82	82	47	47	47	16.601	13.16	14.71
Number of household members	1	1	1	14	8	8	4	4	4	1.79	1.90	1.85
Total household income	500.00	450.00	450.00	32300.00	18000.00	32300.00	5190.17	3132.13	4038.28	2.255	3261.46	5317.69
Distance to market	0.10	0.10	.10	6.80	7.00	7	2.978	2.85	2.91	2.25	2.365	2.31
Number of years fishing	1	-	-	50	-	-	21	-	-	13.72	-	-
Distance to fishing area	.50	-	-	40	-	-	6.9	-	-	10.27	-	-

Ave. price of fish	0	-	-	38.00	-	-	7.94	-	-	11.72	-	-
Ave. quantity of fish sold	0	-	-	960	-	-	70	-	-	157.60	-	-
VDM												
Variables	Minimum			Maximum			Mean			Standard Deviation		
	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH	FH	NFH	TSH
Age	25	29	22	76	94	89	43	49	46	9.84	16.17	14.23
Number of household members	1	2	1	13	13	14	4	5	4	1.90	2.28	2.36
Total household income	700.00	1350.00	850.00	69200.00	20000.0	40000.0	10190.81	6848.49	7742.38	11697.44	4912.25	6528.70
Distance to market	1	0.70	1	17	3	27.80	11.40	1.34	11.59	6.85	0.660	6.35
Number of years fishing	2	-	-	31	-	-	8	-	-	5.94	-	-

Distance to fishing area	.10	-	-	27.2	-	-	4.7	-	-	4.42	-	-
Average price of fish	.00	-	-	25.00	-	-	8.47	-	-	5.19	-	-
Average quantity of fish sold	0.00	-	-	3320	-	-	131	-	-	422.03	-	-

Source: Survey results (2021)

Where: FS represent fishing households, NFH represent non-fishing households, TSH represent total sampled households

Unit of measurements for the variables: Age of household head is measure in years, number of household members is in actual numbers, total household income is measured in Rand per month, distance to market is measured in kilometres, number of years fishing is measured in years, distance to fishing area is measured in kilometres, average price of fish is measured in grams which is sold in Rands, average quantity of fish sold per year it is in kilograms

From the results indicated in Table 4.1, the average household size for fishing, and non-fishing households and the entire sample is 6, 5 and 5 in SDM respectively. On the other hand, the average household size for fishing, non-fishing households and total sampled households in MDM is the same (4 household members). Meanwhile, the average household size in VDM is 4 household members (for fishing households), 5 (for non-fishing households) and 4 household members for the entire sample.

In terms of total household income, the average household income in SDM is R8018.52 per month, while the average household income in MDM is R4032.28 per month. The VDM households have an average monthly family income of R7742.38. In SDM, the minimum income is R1350.00 and the maximum income is R30400.00. Mopani District Municipality has a minimum income of R450.00 and a maximum income of R32300.00. Vhembe District Municipality households' have a minimum income of R850 and a maximum income of R40000.00. This means that the majority of households in SDM, MDM, and VDM earn more than R810.00 per month, which is the lower-bound poverty level (Stats SA Statistics Release, 2019). Fishing and non-fishing households, on the other hand, have average household incomes of R9015.9 and R6348.49 in SDM, respectively. The average household income for fishing and non-fishing households in MDM is R5190.17 and R3132.13 respectively while the average income of fishing and non-fishing households lies between R6800 and R7800.

The maximum distance fishing households travel is 11km, 40km and 27.2km in SDM, MDM and VDM respectively. The minimum distance travelled by fishing households in SDM, MDM and VDM is 0.30km, 0.50km and 0.10km respectively. On average, households are likely to travel 2.5km in SDM, 6.9km in MDM, and 4.7km in VDM so to commence with fishing activities. This suggests that the majority of the households travel shorter distances to the water resources to partake in inland fisheries activities.

In addition, the descriptive data revealed that households in SDM have been active in inland fishing for an average of 14 years, with a minimum of 2 years and a maximum of 32 years. Fishing has been practiced in MDM for an average of 21 years, with a minimum of 1 year and a maximum of 50 years. The descriptive findings also revealed that households had been fishing for an average of 8 years, with a minimum of 2 years and a maximum of 31 years in VDM. The findings indicate that most fishing households have extensive fishing experience.

The results in Table 4.1 also show that the minimum price for selling fish by households involved in inland fisheries is 0 in all the studied districts. This suggests that these households' fish for consumption and not for income generation. The maximum prices of fish sold in SDM, MDM and VDM are R45, R38 and R25 per gram. On average, fish is likely to be sold for R10.26c in SDM, R7.94c in MDM and R8.47c in VDM. These prices depend on the fish type and size measured in grams. The descriptive results also revealed that the maximum number of fish that households sell per year is 1400 in SDM, 960 fish in MDM and 3320 in VDM per kilogram. The average quantity of fish sold kilogram/per year is 178, 70 and 131 in SDM, MDM and VDM respectively.

The standard deviation of total household income in MDM is higher than the mean. These findings imply that the monthly income earned by some households in this district municipality varies. These households may, for example, be self-employed, which means that their income may fluctuate. The standard deviations for distance to fishing places in SDM and MDM, on the other hand, suggest that fishing households in these districts go to various areas to engage in fishing activities. These households are more likely to travel to other communities or municipalities, resulting in long distance travel.

Similarly, the standard deviation for an average selling price of fish captured in SDM and MDM districts suggests that the fishers charge different selling prices for fish. This might be driven by the location, type of fish and which day the fish is sold. Moreover, the standard deviation on the average quantity of fish caught per year is higher than the mean for all the districts. This insinuates that some fishing households are likely to catch more fish per year on a good fishing trip. This might also be influenced by the fishing season in which households carryout their fishing activities. Additionally, these households might also fish at different locations hence, the average quantity of fish caught is higher.

4.1.1. Descriptive results of access to market, credit, extension services and membership of the cooperative

Table 4.2 shows the results of the binary variables in the study which are presented in percentages. These results indicate that in SDM, 83.5% of the sampled households have access to the market while 16.5% do not have access. Only 5.2% of the respondents indicated that they have access to credit while 94.8% indicated that they do not have access to credit in SDM.

Table 4.2: Descriptive results for access to market, credit, extension services and membership of cooperative

District	Variable	Yes (%)	No (%)
SDM	Access to market	83.5	16.5
	Access to credit	5.2	94.8
	Member of cooperative	0	100
	Extension services	0	100
MDM	Access to market	86.6	13.4
	Access to credit	23.9	76.1
	Member of cooperative	0	100
	Extension services	0	100
VDM	Access to market	100	0
	Access to credit	77.5	22.5
	Member of cooperative	5.3	94.7
	Extension services	0	100

Source: Survey results (2020)

According to the results of MDM, 86.6% of households have access to the market, while 13.4 % do not. Additionally, only 23.9% of MDM respondents said they have access to credit, while 76.15% said they do not. According to the descriptive results shown in Table 4.2, all VDM respondents reported having access to the market, with 77.55% having access to credit and 22.55% having no access to credit. These findings suggest that households may be able to save enough money to buy fishing equipment (for fishing households), however studies have shown that households engaged in inland fisheries for consumption use low-cost equipment. Furthermore, having access to the market implies that there is a market where fishers can formally sell fish to make cash, and non-fishing households can purchase fish from these marketplaces. A fishing cooperative represents roughly 5.3% of the fishers in VDM.

In terms of being a member of a fishing cooperative and having access to extension services, the study found that none of the fishing-related households in MDM and VDM are members. This could be due to the lack of laws recognizing inland fishing as an industry that supports rural communities. Inland fisheries could benefit from extension services and cooperatives because involved households might have access to marketing information and government services.

4.1.2. Gender distribution for households not involved in inland fisheries and entire sampled households.

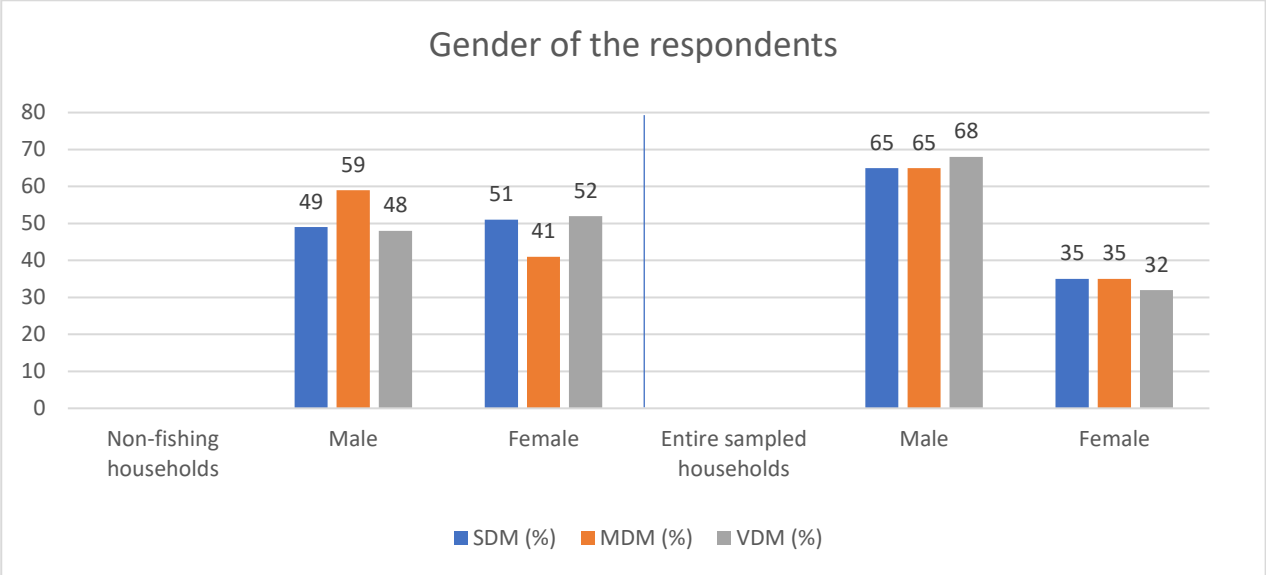

Figure 4.1: Distribution of gender for households not involved in inland fisheries and the entire sample

Source: Survey results (2021)

Figure 4.1 presents the gender distribution of fishing, non-fishing households and the entire sample. The study found that majority of non-fishing households in SDM and VDM are headed by females. In MDM, majority of the non-fishing households are headed by males. The study also found that 65% of the respondents are males and 35% are females in both SDM and MDM. The frequency, however, varied in both of these district municipalities. For example, in SDM, 75 and 40 respondents are males and females, respectively, whereas in MDM, 87 and 47 respondents are males and females. In VDM, the study found that 68% of the respondents as males and 32% are females. The frequencies of the respondents in VDM is 103 and 48 for males and females respectively.

4.1.3. Type of inland fisheries by gender

The descriptive results presented in Table 4.3 shows that both males and females in SDM, MDM and VDM are involved in inland fisheries. In this study, both small-scale and subsistence inland fishers are described separately.

Table 4.3: Type of inland fisheries by gender

Type of inland fisheries	SDM			MDM			VDM		
	Male (%)	Fem. (%)	Permit (both gender)	Male (%)	Fem. (%)	Permit (both gender)	Male (%)	Fem. (%)	Permit (both gender)
Small-scale	26	6	0	80	68	0	70	20	0
Subsistence	74	94	0	20	32	0	23	80	0
Recreational	0	0	0	0	0	0	7	0	0

Where: Fem. is Female

Source: Survey results (2021)

In comparison to females, the majority of males in the study area are engaged in fishing activities. Women are more involved in household administration and family welfare activities than fishing, according to O'Neil and Domingo, (2015); Manyungwa-Pasani *et al.,* (2017); Akhtar *et al.,* (2018). Those involved in fishing, on the other hand, usually entailed capturing fish for consumption (Harper *et al.,* 2020). In SDM, MDM, and VDM, for example, small-scale fishers account for 26%, 80%, and 70% of males, respectively. In SDM, about 6% of females are small-scale fishers, compared to 68% and 20% for MDM and VDM respectively.

Regarding subsistence inland fisheries, about 94%, 32% and 80% of the females' mostly fish for consumption while, 74%. 20% and 23% of the males in SDM, MDM and VDM are also subsistence fishers. In addition, only 7% of the interviewed fishermen in VDM are involved as recreational fisheries while females are not involved. This might be that females have more household responsibilities; hence, they are less involved in recreational fisheries. Lastly, none of the fishers in the three districts reported having permits to catch inland fishes, particularly at the dams. The lack of permits renders the activities performed by these fishing households illegal.

4.1.4. Reasons for being involved in inland fisheries.

Table 4.4 presents the descriptive results concerning the reason why households are involved in inland fisheries by gender. As indicated, the majority of the households (both males and females) in SDM, MDM and VDM catch fish for consumption. This is because about 57%, 66% and 45% of the fishermen mentioned that the reason they are involved in inland fisheries is that it is a source of food. Moreover, about 77%, 55% and 62% of fisherwomen in SDM, MDM and VDM also catch fish for consumption.

Table 4.4: Reason for involvement in inland fisheries by gender

Reason for involvement in inland fisheries	SDM		MDM		VDM	
	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
Consumption	57	77	66	55	45	62
Business	43	23	14	25	36	38
Hobby	0	0	20	20	19	0
Pearson Chi-square	12.57		11.59		34.31	
Probability Chi-square	0.006		0.072		0.000	

Source: Survey results (2021)

Approximately 43%, 14% and 36% of males in SDM, MDM and VDM respectively are involved in inland fisheries for business purposes as compared to 23%, 25% and 38% of females in SDM, MDM and VDM respectively. These households generate income from inland fisheries. Households in the selected districts also mentioned that they view inland fisheries as a hobby. This is presented by 20% of both males and females in MDM and 19% of males in VDM. The Pearson Chi-square of SDM, MDM and VDM resulted in 12.57, 11.59 and 34.31 respectively. The Probability Chi-square amounted to 0.006, 0.072 and 0.000 in SDM, MDM and VDM respectively. These results imply that there are significant differences in the reason both males and females are involved in inland fisheries. Thus, some may participate for consumption purposes and others to generate income or as a leisure activity. These results concur with the findings from World Wildlife United Kingdom [WWF-UK] (2012), that both males and females play different roles in inland fisheries therefore, these roles signify various reasons for participating in inland fisheries.

4.1.5 Type of fish

Table 4.5 shows the results of the type of fish fishers in the study area catch and sell, and the type of fish preferred by households in SDM, MDM and VDM. The study revealed that the common fish caught in all the studied districts is Tilapia. Tapela *et al.,* (2015) also mentioned that Tilapia is the common fish caught by fishers in the Limpopo Province.

In SDM and MDM, the second type of fish caught is Carp, while in VDM, the second preferred fish is Carp followed by Bass. However, in SDM and VDM, 8% and 16% fishers mentioned that they catch Bass. The third type of fish preferred by fishers in SDM is Catfish, while in MDM only 19% fishers mentioned that they prefer Catfish. Furthermore, none of the fishers mentioned catching Eel in both MDM and VDM. Catfish in SDM is mentioned by 28% of the fishers while in VDM, 68% of the fishers mentioned that they catch Catfish in the inland waters. Therefore, Troat is the least mentioned fish by fishers in MDM. In VDM, the least mentioned fishes to be caught by fishers in inland waters are Troat and Tigerfish. None of the fishers in SDM and MDM catches Tigerfish.

Table 4.5: Distribution of fish, consumption and fishing activities for fishing and non-fishing households

Category	SDM	MDM	VDM
	Percentages (%)	Percentages (%)	Percentages (%)
Fishing households			
Type of fish caught			
Tilapia	50	83	85
Carp	44	29	65
Bass	8	75	16
Troat	0	7	5
Catfish	28	19	68
Tigerfish	0	0	8
Eel	15	0	0
How often do you fish			
Occasionally	43	17	31
Sometimes	36	66	37
Always	21	17	32
Where do you normally fish			
State dams	67	83	61
River	33	71	19
Private dams	0	53	19
Non-fishing households			
Where do you buy fish			
Store	50	91	72

Fishers	32	65	18
Traders	13	56	13
Other	0	1	0
Do not eat fish	5	4	7
Type of fish households buy			
Tilapia	58	80	53
Hake	11	23	22
Canned/Tinfish	29	48	52
Carp	2	28	0
Other	0	44	2
Troat	0	5	0
Catfish	0	16	10
Bass	0	0	2
Eel	5	0	0
Do not eat fish	5	4	7

Source: Survey results (2021)

The results presented in Table 4.5 also show that 43% of fishers in SDM mentioned that they fish occasionally, while 36% and 21% fish sometimes and always respectively in this district. In MDM, 17% of fishers mentioned that they perform fishing activities sometimes and occasionally while 66% mentioned that they always fish. On the other hand, about 31%, 37% and 32% of fishers in VDM mentioned that they perform fishing activities occasionally, sometimes, and always respectively.

Concerning where fishers perform fishing activities, it was mentioned by fishers in SDM, that they fish in state dams (67% fishers) and rivers (33% fishers). In MDM, 83%, 71% and 53% of fishers catch fish in state dams, rivers and private dams respectively. About fishers in VDM, 61%, 19% and 19% mentioned that they catch fish in state dams, rivers, and private dams respectively.

The descriptive results also show where households buy their fish. Table 4.5 shows that households in SDM, MDM, and VDM prefer different types of fish from different sources. For example, 50%, 32%, and 13% of SDM households said they prefer to buy fish from stores, fishers, and traders, respectively. In MDM, approximately 91%, 65%, and 56% prefer buying fish from a store, fishers, and traders, respectively. Only 1% of households buy fish from other sources. For households in VDM, about 72%,18% and 13% mentioned that they

purchase fish at stores, fishers and traders respectively. About 5% and 4% in SDM and MDM do not consume fish while in VDM only 7% of the households mentioned that they do not eat fish. Therefore, these results imply that the households who purchase fish from fishers directly gain from the inland water resource. Moreover, the indisputable importance of inland fisheries for food security is then evident in these results.

The results presented also show the type of fish preferred by households who are not involved in inland fisheries in SDM, MDM and VDM. Of all the districts, the most preferred fish is Tilapia, followed by tin fish (canned fish). Tinfish is usually bought at shops as processed fish in a tin (such as Pilchards). Moreover, Carp (mentioned by 28% of the households) and other types of fish (mentioned by 44% of the households) are preferred in MDM. On the other hand, none of the interviewed households in SDM, prefer buying Troat, Catfish and Bass. In MDM, none of the interviewed households prefers buying Catfish, Bass and Eel. None of the households in VDM prefers buying Carp, Troat, and Eel. The least preferred fish by none fishing households in VDM is Catfish and Bass. Figure 4.2 presents some of the types of fish caught by fishers and preferred by households in SDM, MDM and VDM.

	
Mozambique Tilapia (*Oreochromis mossambicus*)	Common carp (*Cyprinus carpio*)

African sharp tooth catfish (*Clarias gariepinus)*

Redbreast Tilapia and Mozambique Tilapia (*Coptodon rendalli*); (*Oreochromis mossambicus*)

Figure 4.2: Different types of fish caught by fishers

Source: Research survey (2021)

4.2. Summary of descriptive statistics

The first part of this chapter presented the results of the study based on achieving objective one which to identify and describe socio-economic characteristics of households and the different roles and functions played along the inland fisheries value chain in the Limpopo Province. The results show that the average age of fishing, non-fishing and the entire sampled households in the study area is between 46 and 49 which suggests that the majority of the households are still in their active stages of life. Moreover, males dominate the fishing sector as compared to females. Although both males and females are involved in fisheries, the reason for involvement differs with the majority of females involved for consumption purposes. The results show that few of the households participate in recreational fisheries but mostly participate for consumption purposes with excess sold for income generation.

Tilapia, Carp, Bass and Catfish seems to be the preferred fish species by fishers and some households. Although inland fishing takes place in the study area, some households are only consumers of the fish and do not take part in actual fishing. However, these households purchase inland fish from fishers, traders, and processors. On the contrary, none of the fishers reported to have access to extension services. This can be attributed to the lack of policy that recognises the significance of the sector to rural livelihoods. Despite this

challenge, it can be said that inland fisheries are a livelihood activity for both males and females in the study districts.

4.3. Role players of inland fisheries in SDM, MDM and VDM

The results presented in Table 4.6 show the different role-players of the inland fisheries value chain and their functions. In this study, role players refer to the households both engaged in inland fisheries and those not engaged. However, those not engaged are mostly consumers of fish. The study found that fishers play multiple roles within the inland fisheries value chain. The role players identified are input suppliers, fishers, traders, processors and consumers.

The results show that in SDM, MDM and VDM, input suppliers have been identified. The function of the input supplier is to provide inputs (bait, gear, rods, hooks, nets, fridge, boat, fuel, transport) to the fishers. This activity act as a pre-harvesting activities. Moreover, the roles of fishers include catching the fish (about 72, 59 and 62 in SDM, MDM and VDM fishers respectively), processing fish, packaging and transportation, marketing and distribution, and warehousing. These fishers also sell fish to traders and consumers. The majority of the fishers store the fish in refrigerators (a form of warehousing) for preservation. The roles of the fishers also involve being price makers and takers. Concurrently, these fishers also consume the fish they harvest. Of the households who catch the fish, about 51%, 88% and 82% in SDM, MDM and VDM respectively consume the fish caught. The one hundred percent shown in Table 4.6 implies that all the interviewed role players perform the particular function.

Table 4.6: Role players of inland fisheries and related function

	Role players	Function	SDM (%)	MDM (%)	VDM (%)
Pre-harvesting	Input suppliers	Sell inputs (bait, gear, rods, hooks, nets, fridge, boat, fuel, transport) to fishers	100	80	0
		Loan inputs	0	100	100
		Repair inputs	0	20	11
		Provide guidelines on how to use the inputs	0	40	0
		Deliver inputs to the fishers	0	0	0

Post harvesting	Fishers	Catch fish (NPHAF)	100	100	100
		Sell raw fish to traders/consumers	42	42	60
		Process the fish for selling	6	15	5
		Price maker	4	3	21
		Price taker	42	31	0
		Consume fish	51	88	82
		Warehouse	90	88	97
		Packaging and transportation	0	0	13
		Marketing and distribution	0	0	8
	Traders	Purchase fish from household/ fishers	40	38	67
		Sell fish to consumers, Process fish	100	100	100
	Processors	Gut the fish, dry/fry fish, Sell fish to consumers	100	100	100
	Consumers	Purchase fish from fishers	50	68	19
		Purchase fish from traders	20	58	14
		Price takers	65	58	1

Note: NPHAF means ‘not a post-harvesting activity but actual fishing’

Source: Survey results (2021)

The results in Table 4.6 also show the functions of traders within the inland fisheries value chain in the Limpopo Province. For instance, the results show that traders process fish and sell it to consumers. However, some of these traders purchase fish from fishers. The study found all the identified traders in SDM, MDM and VDM sell and process fish.

The study found that processors in SDM, MDM and VDM perform functions such as gutting, drying/frying and selling fish to consumers. These processors each take 100% of these functions. These processors are usually traders who perform these activities in preparation for selling to customers. Therefore, there seem to be similar functions played by traders and processors.

The majority of the households play multiple functions in the value chain of inland fisheries. This is also true as most of the households engaged in inland fisheries are also consumers of the fish they harvest. As it can be seen from Table 4.6, about 20%, 58% and 14% in SDM,

MDM and VDM of the consumers purchase fish from traders respectively. These consumers are mostly price makers. This proposes that most consumers negotiate the price when buying fish.

4.3.1. Relationship between socio-economic characteristics of role players and their functions along the value chain

Table 4.7 presents the results for the relationship between socio-economic characteristics of role players and their functions along the inland fisheries value chain. The Pearson Chi-square test was used to obtain the results for the relationship between gender and socio-economic characteristics. On the other hand, the Pearson Product Moment was employed to determine the relationship between age and functions of role players. The results indicate that there is a relationship between gender and the functions of traders and consumers. Additionally, the results show that there is a correlation between age and functions of input supplier, processor and consumer.

Table 4.7: Relationship between socio-economic characteristics of role players and their functions in SDM, MDM and VDM

District	Input supplier	Fishers	Trader	Processor	Consumer
Pearson Chi-square (Gender vs functions of role players)					
SDM	.561	.558	.094	.555	.040**
MDM	.726	.108	.090*	.409	.477
VDM	.274	.994	.871	.678	.0.004***
Pearson Correlation coefficient (Age vs functions of role players)					
SDM	(-.083).489	(.198).112	(-.203).601	(.039).749	(.247).224
MDM	(-.173).189	(.006).962	(.420).300	(.329).012**	(.025).866
VDM	(.293).021**	(-.185).150	(.171).183	(.176).170	(.336).080*

Note: ***, **, * represent significance level at 1%, 5% and 10%. Values in parentheses are the correlation coefficients)

Source: Survey results (2021)

4.3.1.1. Pearson Chi-square results (Gender vs functions of role players)

a) Relationship between gender and trader function (SDM)

The gender and functions of traders in the value chain were assessed. The results show that there is a statistically significant relationship ($p>0.05$). These findings propose that both male and female traders are likely to perform the same duties along the inland fisheries

value chain. According to Mamun-ur-Rashid and Gao (2012), the function of a trader/retailer is mostly undertaken by females as compared to males. Following Pizzali (2001), both men and women are involved in street vending mostly as a family business.

b) Relationship between gender and function of consumer

The relationship between gender and the function of consumers was estimated. The results show a statistical significance of 5% and 1% in SDM and VDM respectively. The results imply that both male and female fish consumers have similar functions along the value chain. For instance, both might purchase fish from fishers or fish traders. Moreover, the intake of fish is associated with a healthy diet for both males and females (Wennberg *et al.,* 2012).

4.3.1.2. Pearson Correlation coefficient results (Age vs functions of role players)

a) Correlation between age and input supplier function (in VDM)

The correlation between age and input supplier function was estimated and the results show that there is a statistical significance between age and input supplier function VDM. The results presented a correlation coefficient of $r=.293$ and $p<0.05$. The significance level is at 5%. The direction of the relationship is positive which means that these variables tend to increase together. The magnitude of the association is low. The results imply that as the age of the role player increases, they are likely to be responsible enough to take on more functions as an input supplier. For example, age is associated with experience, which means that the role player might have enough skills to take on more functions as an input supplier in the value chain of inland fisheries. Therefore, a lack of skills will result in poor and inadequate input supply for fisheries (Kassam *et al.,* 2017).

b) Correlation between age and processor function (in MDM)

Age and processor function in the value chain of inland fisheries was measured. The results show that there is a statistical positive significant relationship ($r=.329$, $p<0.05$). The direction of the relationship is positive. However, the magnitude of the association is low. The results imply that as the age of the processor increases, more processor functions in the value chain might be adopted. This is because the processor might have acquired more knowledge through the years so to take on more processing responsibilities. Olutusmise *et al.,* (2020) found that many fish processors still use traditional methods of processing fish such as sun drying. This then influences participation in processing fish due to climate.

c) Correlation between age and consumer function (in VDM)

The correlation between age and function of a consumer within the inland fisheries value chain resulted in a positive association. The results show that there is a statistically significant relationship between age and the function of consumers (r=.336, p>0.05). The magnitude of the association is low. The results suggest that as the age of the consumer increases, the likelihood of performing functions such as knowing where to buy fish (inland fish traders or fishers) also increases. Quagrainie *et al.,* (2009) found a significant relationship between the age of the consumer and the consumption of fish. For instance, the results revealed consumers prefer inland fish to farmed Tilapia and Catfish. Quagrainie *et al.,* (2009) found that consumption of fish is significantly dependent on age among other variables.

4.4. Inland fisheries value chain results

This section discusses the inland fisheries value chain map in the Limpopo Province. Figure 4.3 shows the value chain map of inland fisheries in the study area.

In this study, inland fisheries activities were identified at both dams and rivers. Moreover, the value chain of fisheries differs by fish species and location (De Silva, 2011). Therefore, this study provides a general inland fisheries value chain of the Limpopo Province. In this study, the main focus of the value chain is the roles played by both fishing and none fishing households.

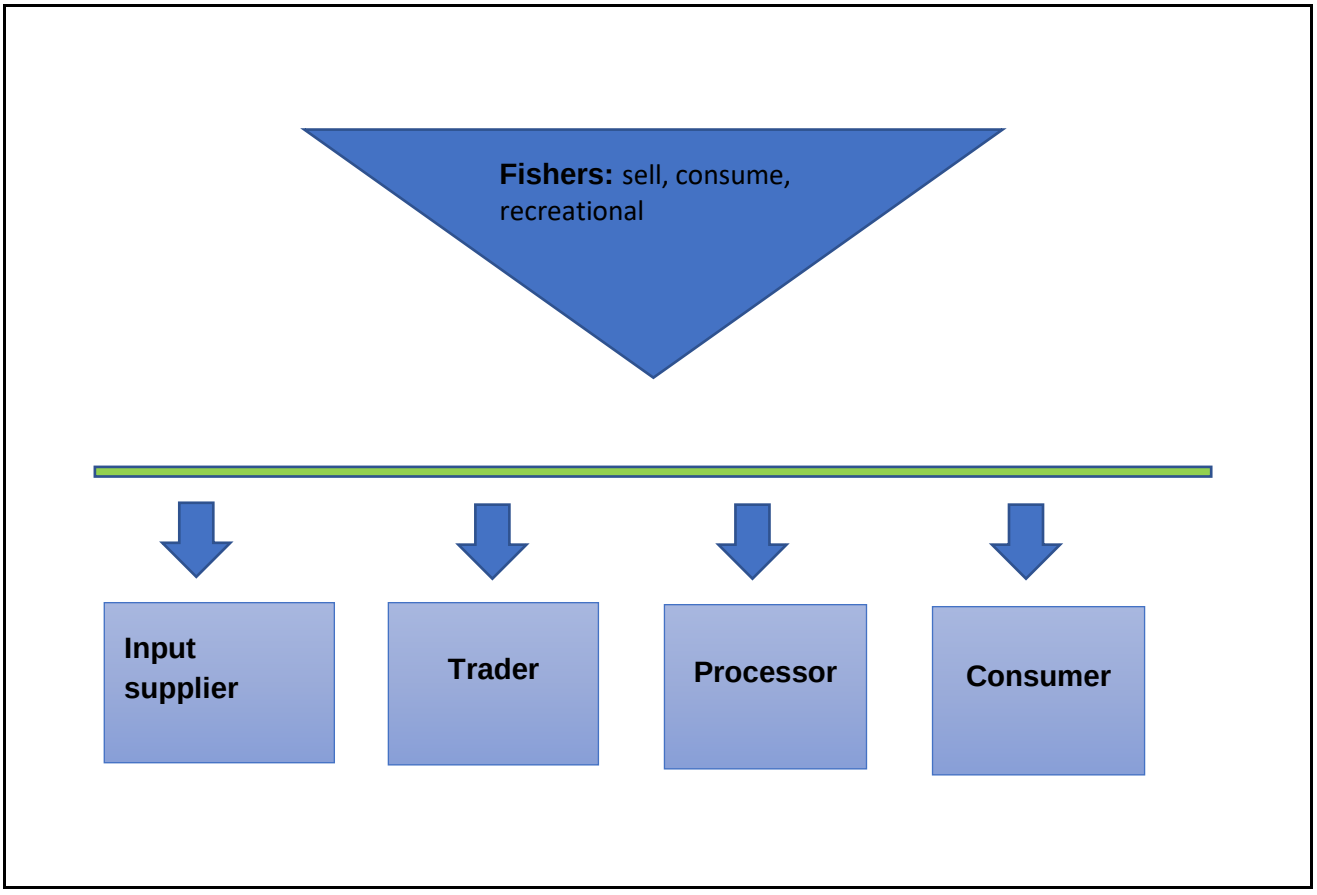

Figure 4.3: Inland fisheries value chain diagram in Limpopo Province

Source: Own compilation (2021)

In other parts of the Sekhukhune District, the study found that fishing is an open access activity (for example Mantshohlong Dam). In some cases, illegal access to fishing resources where identified. For example, in the Sekhukhune District Municipality, routes leading to fishing resources were identified under a bridge below the Flag-Boshielo Dam wall (Figure 4.4). However, this access to fishing is deemed informal and illegal (Britz *et al.,* 2015; Muchopondwa *et al.,* 2021). As a result, to access the dams, fishers are expected to get permits. For instance, the Department of Water and Sanitation (DWS) is responsible for dam management in all state dams (Muchopondwa *et al.,* 2021). This is because the main purpose of the dam-building was for households to access water for domestic, irrigation and agricultural purposes (Tapela *et al.,* 2015). Local authorities such as the chiefs are responsible for permitting to access the main routes to the dams. Therefore, these two authorities can act as supporters and influencers of inland fishing households. However, the majority of the fishers mentioned that they lack permits to access the dams.

Figure 4.4: Fishing routes and a fisherman below the Flag-Boshielo Dam wall
Source: Research survey (2021)

Additionally, the value chain diagram in Figure 4.3 shows that fishers are involved in the actual harvesting of fish. These fishers participate in inland fisheries for three purposes *viz.* sell, consume and recreational. However, these fishers play multiple roles and functions

within the inland fisheries value chain. For example, they not only act as fishers, but also supply inputs, and are traders, processors, and consumers.

Fishers can purchase inputs such as modern rods and nets at the nearest towns. However, other fishers make their fishing equipment to cut costs. The fishers in this case are the households involved in inland fisheries. These households sell the caught fish to traders, processors, and consumers.

In turn, there are also those households who are purely traders of fish. These traders also play the dual role of being processors. However, few of these households were identified by this study. In addition, the fishers sell the raw fish to consumers. These consumers might be those who are involved in inland fisheries (particularly if they rely on fisheries for food and income) and those who do not participate.

According to Britz *et al.,* (2015), the value chain of inland fisheries is short with little evidence of post-harvest value addition. This study, however, identified that households play multiple roles that range from the actual catching of fish to being traders, processors, and consumers altogether. For instance, the function of traders and processors is to gut and cook the fish for selling. Moreover, the fishers also gut the fish for preservation purposes.

Despise this value addition, market access has been identified as one of the challenges that face inland fisheries, particularly in South Africa, thus value chain analysis assists producers to identify possible markets along the fisheries value chain (Muchopondwa *et al.,* 2021). Figure 4.5 shows informal markets for selling raw and processed fish in the Sekhukhune and Mopane Districts.

Figure 4.5: Informal markets for selling inland fresh and processed fish
Source: Research survey (2021)

4.4.1. Value chain patterns channel of inland fisheries in the Limpopo Province

Table 4.8 describes the inland fisheries value chain patterns in Limpopo Province. The study discovered that the value chain patterns of inland fisheries are simple because inland fisheries are mostly for domestic consumption. Moreover, no formal markets for selling inland fish exist in the three studied districts. None of the fish caught within the inland fisheries was imported. The important chain actors involved in the inland fisheries are input suppliers, fishers, traders, processors and consumers.

Table 4.8: Inland fisheries value chain patterns in Limpopo Province

Patterns	Inland fisheries marketing chain actors
Pattern 1	Input suppliers→ fishers
Pattern 2	Fishers → traders→ consumers
Pattern 3	Fishers →processors → consumers
Pattern 4	Fishers → consumers

Source: Own compilation (2021)

Four marketing patterns were identified. The first pattern shows that input suppliers supply inputs such as gears, rods, and nets to the fishers. Secondly, pattern 2 shows that fishers sell fish to traders then the traders will sell to consumers. Pattern 3 shows that fishers sell

fish to processors who then sell it to consumers as ready-for-consumption fish in the form of dried/fried/salted fish. Finally, pattern 4 shows that fishers catch fish and sell it directly to consumers. To this end, these findings agree with the discoveries of Tapela *et al.,* (2015); Britz *et al.,* (2015) who found that the inland fisheries value chain in South Africa is short.

4.5. Summary of inland fisheries value chain

This chapter focussed on the value chain of inland fisheries. This chapter aims to answer objective one of the study which is to identify and describe the different roles played by household and their function along the inland fisheries value chain in Limpopo Province. The study used descriptive statistics, Pearson Chi-square and Pearson Correlation Coefficient to achieve this objective.

The study found that 72, 59 and 62 households in SDM, MDM and VDM practice inland fisheries respectively. In addition, the majority of these households are price takers. Although not all households sell the fish they have caught, consumption seems to be the driving force towards participating in this sector.

The Pearson Chi-square revealed a relationship between gender and functions of trader and consumer. Pearson's Product Moment Correlation showed that the age of the household head has a relationship with the function of a consumer input supplier and processor. Furthermore, the study identified that fisher households are involved in both pre- and post-harvesting activities. The pre-harvesting activities involved the functions of a supplier. That is to sell inputs, repair, and loan inputs. The post-harvesting activity included the selling of raw fish, fish processing, fish trading and consumption.

Additionally, the study found that the value chain of inland fisheries is short with households having multiple roles. The main actors of the value chain were identified as input suppliers, fishers, traders, processors, and consumers. Also, the study revealed four marketing patterns of inland fisheries, these include input suppliers who sell inputs to fishers, fishers who sell raw fish to traders then the traders sell to consumers. Thirdly, fishers would raw fish to processors who will sell it to consumers. Finally, fishers directly sell to consumers. These marketing patterns show the available markets that fishers use to generate income. Therefore, more marketing channels should be promoted so that households can generate income and possibly create employment within their communities.

4.6. Contribution of inland fisheries to household income

This section presents the results for the contribution of inland fisheries to household income.

4.6.1. Share of income to total household income

Table 4.9 presents the share of income to the total household income in SDM, MDM and VDM in the Limpopo Province. The results are only based on households participating in inland fisheries. The share of income to the total household income serves as a proxy of the contribution of inland fisheries to the total household income.

Table 4.9: Share of income to total household income

Source of income	SDM (%)	MDM (%)	VDM (%)
Non-fishing income sources			
Crop production	0.8	2.1	0.3
Livestock production	4.0	7.2	2.0
Social grants	9.0	14.8	1.3
Remittances	4.0	1.5	2.1
Self-employed	27.5	29.0	27.0
Wage-earnings	24.0	16.4	28.0
Other non-fishing income sources	2.0	0.9	0
Fishing income sources			
Loaning of fishing inputs	0	0.4	4.0
Selling fishing inputs	0.5	0.2	0
Repairing fishing inputs	0	0.1	0.05
Packaging and transportation	0	0	1.65
Marketing and distribution	0	0	0.9
Selling processed fish	3.5	4.1	9.3
Selling raw fish	24.7	23.3	23.4
Other fishing income sources	0	0	0

Source: Survey results (2021)

The percentage contribution of non-fishing and fishing incomes to total household income is shown in Table 4.9 Crop production accounts for approximately 0.8% and 2.1% in SDM and MDM, respectively. In VDM, however, this source of income contributes only 0.3% of total household income. Livestock, on the other hand, contributes 4.0%, 7.2%, and 2.0% of

total household income in SDM, MDM, and VDM households, respectively. Furthermore, only 2% and 0.9% of income from non-fishing sources contribute to total household income in SDM and MDM, respectively.

According to the findings, self-employment appears to contribute more income to total household income in SDM (27.5%) and MDM (29.0%). Wage earnings also contributes more to total household income in SDM (24.0%) and MDM (16.45). Wage earnings are the largest contributor to total household income in VDM (28.0%), followed by self-employment (27.0%). Social grant income accounts for 9.0%, 14.85, and 1.3% of total household income in SDM, MDM, and VDM, respectively.

The results presented in Table 4.9 also show the contribution of fishing activities to total household income. The results show that loaning of fishing inputs such as rods, lines, nets etc. contributes 0.4% and 4% to total household income in MDM and VDM respectively. Only 0.5 and 0.2% households in SDM and MDM sell fishing inputs such as rods, hooks, nets respectively. These findings suggest that most fishing households use different inputs for fishing activities. Similarly, repairing fishing inputs contributes about 0.1% and 0.05% to the total household income in MDM and VDM respectively.

It is also observed from Table 4.9 that packaging and transportation, marketing and distribution does not contribute to the total household income in both SDM and MDM households. However, these activities contribute to the total household income in VDM (about 1.65% for packaging and transportation and 0.9% for marketing and distribution).

A household who sells processed fish contributes about 3.5%, 4.1% and 9.3% to total household income in SDM, MDM and VDM respectively. This suggests that there are post-harvesting activities that households are engaged in that contribute to total household income in the studied districts. The most fishing activity that contributes to total household income is the selling of raw fish. This activity contributes 24.7%, 23.3% and 23.4.% in SDM, MDM and VDM respectively. There are no other sources of fishing income mentioned by all the households in the studied districts. Katiha *et al.,* (2014) also established that fishing is a source of income for the majority of households in India, followed by business, agriculture, and labour services. To this end, the results presented in Table 4.9. shows the distribution of income diversity by fishing households in the study area.

	
Homemade raft	Fisherman with a hand-made fishing rod.
	
Fisherman using a basin to assess the fish net	Morden and home-made fishing rods
	
Nets and fish bait	Modern fishing nets and rods

Figure 4.6: Home-made and modern fishing inputs used by fishers in the study area

Source: Research survey (2021)

4.6.2. Level of income diversification for households involved in inland fisheries

The results in this section are for the level of income diversification for households involved in inland fisheries in SDM, MDM and VDM. The results are presented and discussed.

Table 4.10: Level of income diversification in SDM, MDM and VDM

SID values	Diversification level	SDM (%)	MDM (%)	VDM (%)
≤0.01	No diversification	29.2	44.1	22.6
0.01-0.25	Low	8.3	6.8	24.2
0.26-0.50	Medium	45.8	37.3	24.2
0.51-0.75	High	15.3	11.8	27.4
>0.75	Very high	1.4	0	1.6
Average level of diversification		0.303	0.247	0.322

Source: Survey results (2021)

Table 4.10 resents the results of level of income diversification for inland fisheries' households in SDM, MDM and VDM. The results were obtained using the Simpson Index Diversity (SID).

The results indicate that about 29.2% of households in SDM have not diversified their livelihoods. This suggests that these households only have a single source of income.. On the other hand, 44.1% and 22.6% of the households in MDM and VDM have also not diversified their livelihoods respectively. About, 8.3%, 6.8% and 24.2% of the households in SDM, MDM and VDM have low diversity respectively. Concerning medium livelihood diversity, the study found that the majority of the households in SDM (45.8%) and MDM (37.3%) have medium diversity. This suggests that these households do not rely on inland fisheries as a source of income alone.

Rahman *et al.,* (2011); Parashar *et al.,* (2016); Oladimeji (2018) also found that households engaged in fisheries have multiple sources of livelihood. This is because these households need to have strategies to minimise the risk of fish scarcity, climate change and market uncertainty. Moreover, about 24.2% of households in VDM also have medium diversity. Additionally, 15.3%, 11.8% and 27.4% of the households in SDM, MDM and VDM have high diversity respectively. Few of the households engaged in inland fisheries have a very high level of diversity. For instance, 1.4% of the households in SDM and, 1.6% of households in VDM have very high diversity. This also suggest that these households have multiple sources of livelihood. However, none of the fishing households in MDM has high income

diversity. On average, households are likely to have medium diversity of income in both SDM and VDM, while households in MDM are likely to fall in the low level of livelihood diversity. To this end, households in SDM, MDM and VDM somewhat contribute to the total household income through fishing activities.

4.7. Multiple linear results for SDM, MDM and VDM

To analyse the factors that influence the household income of inland fishing households, a Multiple Linear Regression model (MLRM) was employed. Moreover, to assess whether the included variables exhibit multicollinearity, the Variance Inflation Factor (VIF) was carried out. The VIF identifies collinearity between the independent variables and the strength of their correlation. The VIF observations with a value of 1 have little multicollinearity where else values above 5 are strongly correlated (Sgro *et al.,* 2019). As indicated from the MLRM results of SDM, MDM and VDM, none of the variables show multicollinearity. The results indicate that all the fitted variables do not display multicollinearity as indicated by the collinearity test results (VIF and Tolerance).

The adjusted R^2 in Table 4.11 imply that 24.4%, 41.6% and 66.2% of the variance in the data of SDM, MDM and VDM can be explained by the predictor variables, respectively. The standard error of the estimates in Table 4.11 measures the precision on the model. It is the standard deviation of the residuals. The Analysis of Variance (ANOVA) results (F-ration and Significance) indicate the overall significance of the model.

The F-ration in the ANOVA is meant to test whether the overall regression model is a good fit for the data. As shown in Table 4.11, the results show that the F-ration for the independent variables statistically and significantly predict the dependent variable in SDM, MDM and VDM.

Table 4.11: Model fit results for Multiple Linear Regression

District	R^2	Adjusted R^2	Standard error of the estimate	Mean VIF	ANOVA F-ration	ANOVA Significance
SDM	.393	.244	6542.759	1.746	2.633	.005
MDM	.560	.416	4810.487	1.546	3.905	<.001
VDM	.740	.662	7983.928	1.827	9.536	<.001

Source: Survey results (2021)

4.7.1. Multiple Linear results for SDM

Table 4.12. shows the MLRM for SDM. The results are for all the significant variables are discussed in this section. The results show that marital status and distance to the market are significant factors that influence the household income of inland fishing households.

Table 4.12: Multiple linear results for SDM

Variables	B	Std. Error	t	Sig.	Collinearity Statistics	
					Tolerance	VIF
Constant	14524.512	9317.573	1.559	.125		
Age of household head	-98.502	73.758	-1.335	.187	.604	1.655
Gender of household head	-2936.075	2003.990	-1.465	.148	.790	1.266
Number of household members	473.676	340.944	1.389	.170	.760	1.315
Marital status	1839.739	818.319	2.248	.028**	.654	1.530
Level of education	717.062	876.108	.818	.417	.712	1.404
Access to credit	-3219.154	3614.538	-.891	.377	.867	1.153
Distance to market	3758.961	1427.050	2.634	.011**	.755	1.325
Number of years fishing	-156.380	115.497	-1.354	.181	.763	1.311
Distance to fishing area	-562.497	371.385	-1.515	.135	.399	2.507
How often do you fish	1441.656	1423.915	1.012	.316	.497	2.010
Type of inland fish involve in	-1575.169	1170.867	-1.345	.184	.798	1.253
Reason for fishing	-241.767	541.813	-.446	.657	.593	1.687
Average selling price of fish	-80.180	116.958	-.686	.496	.258	3.878
Average quantity of fish caught	6.671	4.028	1.656	.103	.465	2.148

Note: ** indicate significance level at 5%

Source: Survey results (2021)

a) Marital status

The MLRM in Table 4.12 Indicate that the variable marital status has a positive and statistically significance at 5% level. The findings imply that when the household head is married, the household income rises. Similarly, a household head who fishes and is married to a working spouse has a better chance of increasing household income than the unmarried. The argument in this case is predicated on the assumption that married household heads can contribute to the total household income alongside their spouse. A study conducted by Dunga (2017) confirmed that married people have a higher income than unmarried people. The findings are consistent with those of Ayantoye *et al.,* (2017) and Etuk *et al.,* (2018). Munhenga (2014) attests to the importance of the marital status of the household head in determining livelihood strategies.

b) Distance to market

At the 5% level, the variable distance to the market was found to be positively significant. Keeping all other variables constant, a one-kilometre increase in distance to the market raises the income of fishing households by 3758.96 units. This is surprising because traveling a longer distance to the market increases transportation costs. According to Huong *et al.,* (2016), fish farmers prefer selling fish to nearby markets because they can save time and transactional costs.

4.7.2. Multiple Linear results for MDM

This section discusses the MLRM results for the Mopani District Municipality. As indicated from the results emanating from Table 4.13, only the average quantity of fish caught per year is positive and statistically significant at 1%.

Table 4.13: Multiple linear results for MDM

Variables	B	Std. Error	t	Sig.	Collinearity Statistics	
					Tolerance	VIF
Constant	1125.571	6708.668	.168	.868		
Age of household head	4.338	52.079	.083	.934	.542	1.844
Gender of household head	2485.499	1729.625	1.437	.158	.668	1.498
Number of household members	237.152	388.487	.610	.545	.834	1.200
Marital status	-1715.960	1012.814	-1.694	.097	.675	1.480
Level of education	41.310	637.303	.065	.949	.809	1.236
Access to credit	1721.078	1870.473	.920	.363	.742	1.348
Distance to market	-227.442	335.226	-.678	.501	.699	1.430
Number of years fishing	-34.450	67.663	-.509	.613	.561	1.783
Distance to fishing area	-56.534	77.272	-.732	.468	.746	1.341
How often do you fish	-842.941	1278.958	-.659	.513	.707	1.414
Type of inland fisheries	69.788	1851.879	.038	.970	.480	2.085
Reason for fishing	-160.012	280.576	-.570	.571	.562	1.780
Average selling price of fish	-14.194	8.365	-1.697	.097	.609	1.642
Average quantity of fish caught	23.349	5.016	4.655	.000***	.638	1.566

Note: ***, ** indicate significance level at 1% and 5% respectively

Source: Survey results (2021)

a) Average quantity of fish

At the 1% level, the variable average quantity of fish is positive and significant. These findings imply that a one-unit increase in the average number of fish caught per year will increase the household's income by 23.35 %. The argument goes that the more fish a household catches, the more money it makes. Thus, this contribution increases the

household income. According to Mafimisebi *et al.,* (2015), the quantity of fish caught influences household income through fish hunting and fish marketing.

4.7.3. Multiple linear results for VDM

The MLRM results for VDM indicate that access to credit, distance to the market, number of years fishing, type of inland fisheries, reason for fishing and average quantity of fish caught per year are significant in influencing the household income of inland fishing households.

Table 4.14: Multiple linear results for VDM

Variables	B	Std. Error	t	Sig.	Collinearity Statistics	
					Tolerance	VIF
Constant	20821.037	12014.971	1.733	.090		
Age of household head	3.541	143.706	.025	.980	.523	1.912
Gender of household head	-8255.770	4863.540	-1.697	.096	.586	1.706
Number of household members	-1286.710	880.549	-1.461	.151	.372	2.686
Marital status	115.387	1160.219	.099	.921	.729	1.371
Level of education	-277.628	1993.536	-.139	.890	.624	1.602
Access to credit	-9640.407	4045.263	-2.383	.021**	.627	1.594
Distance to market	357.360	186.375	1.917	.061*	.641	1.561
Number of years fishing	572.704	268.911	2.130	.038**	.409	2.445
Distance to fishing area	98.694	312.152	.316	.753	.548	1.823
How often do you fish	1389.305	1766.095	.787	.435	.524	1.908
Type of inland fisheries	2715.524	1560.092	1.741	.088*	.457	2.190
Reason for fishing	-1426.651	631.039	-2.261	.028**	.570	1.755
Average selling price of fish	263.974	242.254	1.090	.281	.590	1.696

Average quantity of fish caught	16.170	2.798	5.779	.000***	.749	1.334

Note: ***, ** indicate significance level at 1% and 5% respectively

Source: Survey results (2021)

a) Access to credit

Access to credit is negatively and statistically significant at a 5% level. The results suggest that a 1 unit decrease in the access to credit will decrease the households' income by 9640.407 units. The implication is that the inability of the fishing household to acquire credit will decrease their household income. This is because the access to credit will enable the fishing household to purchase fishing equipments to participate in fishing activities for income generation. Moreover, access to credit will enable the household to pay for household expenses, especially during low fishing season. In addition, access to credit will motivate the household to participate in fishing activities which will in turn generate income (Hailu *et at.,* 2017). Zella and Mpemba (2017) found contradicting results.

b) Distance to the market

The variable distance to the market resulted in a positive and statistical level of 10%. Likewise, the results imply that an additional kilometre to the market will increase the income of households by 357.360 units. According to Alemu and Azadi (2018) distance to the market is a driving force that facilitates access to the market. Thus, when the distance to the market is longer, this might hinder the households' ability to access the market which will in turn affect the profit generated from fisheries. Ultimately, the household income will be compromised.

c) Number of years fishing

The results in Table 4.14 show that the number of years fishing is positive and significant at 5%. The results imply that a 1 year increase in fishing experience will increase the household income of fishers by 572.704 units. This is to say, the more years households have in inland fishing activities will allow them to know the tricks of increasing income through activities such as selling raw fish and loaning inputs. Putria and Wulandari (2020) also found the level of fishing experience has a significant effect on fisher's income. In the same notion, Amevenku *et al.,* (2019) also found that experience in fishing is a major factor that influences income diversity among fishing households in Volta Basin, Ghana.

d) Type of inland fisheries

The MLRM results show that the variable type of inland fisheries the households participate in influences their income. For example, the coefficient means that as the household moves closer to small-scale fisheries, the household income will increase by 2715.524 units. The study identified different types of inland fisheries that households are involved in (that is, small-scale, subsistence and recreational). Olale and Henson (2012) also found that the type of fish work that households are involved in influences the decision to diversify livelihoods which ultimately increases household income.

e) Reason for fishing

The variable reason for fishing is negative and statistically significant at a 5% level of significance. The study identified three reasons for households' engagement in inland fisheries which are consumption, business and hobby (recreational purposes). It is without a doubt that households who engage in inland fisheries for business purposes will increase their household income. However, households who are involved in recreational fisheries, are likely to have other sources of income. According to Martin *et al.,* (2013); Mills *et al.,* (2017), participating in fisheries activities improves the income and livelihoods of households

f) Average quantity of fish caught

The variable average quantity of fish caught by inland fishing households is positive and statistically significant at a 1% level. The results suggest that an increase in the number of fish that households catch per year will increase the household income by 16.17%. This implies that the more fish caught per year, the more income generated. However, households that catch few fish, are likely to have less income if they depend mostly on fisheries for livelihood. Additionally, the deficiency of fish within the inland water resources is likely to decrease the income of fishing households but the surplus will increase their income (Magego, 2012).

4.8. Summary of the contribution of inland fisheries to household income

The study found that households involved in inland fisheries diversify their income. The results show that most of the households involved in inland fisheries have both fishing income and non-fishing income sources. For instance, self-employment and wage earnings contribute more to the total household income as non-fishing income sources. Moreover, selling processed and raw fish also contributes more to the household's income. On average, households in SDM and VDM have medium income diversity compared with

households in MDM who have low-income diversity. This suggests that most households involved in inland fisheries in MDM have a single source of income. The results, therefore, validate prior findings by literature that inland fisheries contribute to household income.

The study further found that there are various factors that influence the household income of inland fishing households in the study area. A Multiple Linear Regression model was employed to analyse these factors. The results show distance to the market, average quantity of fish caught per kg/year, access to credit, number of years fishing and type of inland fisheries positively influence the income of fishing households. On the other hand, reason for fishing negatively influence the income of fishing households. Surprising results are for distance to the market which is positive and significant. This variable was expected to be negative since longer distance to the market increases transactional costs. In addition, the results from the analysis confirm that inland fisheries contribute to the income generation of households involved in inland fisheries.

4.9. Contribution of inland fisheries to households' food security

This section presents food security results were the HDDS, HFIAS, binary logistic and multinomial logistic results are discussed.

4.9.1. Household Dietary Diversity and Household Food Insecurity Access Scales by type of inland fisheries results for households involved in fisheries and those who are not involved.

Table 4.15 presents the Household Dietary Diversity and Household Food Insecurity Access Scales by type of inland fisheries of households involved in fisheries and those who are not involved. The Pearson Chi-square (significant at 95% level) results illustrate if there are significant differences between the two groups oof households. The results of the Pearson Chi-square indicates that there are no significant differences between the food security status and dietary diversity of households involved in fisheries and those not involved. As evident in the results below, in SDM and MDM, none of the interviewed households is involved in recreational inland fisheries.

Twenty percent of the households involved in small-scale fisheries in SDM are food secure where else 60% and 20% are mildly food insecure and moderate food insecure respectively. None of the small-scale fishers is reported as severe food insecure. From the subsistence fishers, two percent and 98% of the households have a low dietary diversity and high dietary diversity respectively. Moreover, from the subsistence fishers, 30% are food secure while

33%, 23% and 14% are mildly, moderate and severe food insecure respectively. Moreover, from those who are not involved in inland fisheries, approximately 9% of the households have low dietary diversity and 91% have high dietary diversity respectively. In addition, about 26%, 30%, 26% and 18% of the households not involved in fisheries reported to be food secure, mildly food insecure, moderately food insecure and severe food insecure respectively.

Table 4.15: Comparison of Household Dietary Diversity and Household food insecurity access scales by type of inland fisheries

District	Type of inland fisheries	Household Dietary Diversity		Household food insecurity access scales			
SDM		LDD (%)	HDD (%)	Food secure (%)	Mildly food insecure (%)	Moderate food insecure (%)	Severe food insecure (%)
	Small-scale	13	87	20	60	20	0
	Subsistence	2	98	30	33	23	14
	Recreational	0	0	0	0	0	0
	None	9	91	26	30	26	18
MDM	Small-scale	8	92	0	23	23	54
	Subsistence	9	91	4	17	13	66
	Recreational	0	0	0	0	0	0
	None	12	88	7	13	23	57
VDM	Small-scale	2	98	59	7	24	10
	Subsistence	3	87	63	0	0	37
	Recreational	0	100	67	0	0	33
	None	4	96	49	7	14	30
Food security difference			Probability				
SDM probability			<0.001				
MDM probability			0.056				
VDM probability			0.055				

Source: Survey results (2021)

In MDM, only 8% and 92% of the households involved as small-scale fishers have low dietary diversity and high dietary diversity respectively. None of the small-scale fishers reported being food secure. However, about 23%, 23% and 54% of the households reported being mild, moderate and severe food insecure respectively. Moreover, 9% and 91% of the subsistence fishers have low dietary diversity and high dietary diversity respectively. Additionally, 4%, 17%, 13%, and 66% of the households involved as subsistence fishers reported being food secure, mild, moderate and severe food insecure respectively. Furthermore, 12% and 88% of the households not involved in inland fisheries have low dietary diversity and high dietary diversity respectively. About, 7%, 13%, 23% and 57% of non-fishing households reported being food secure, mildly, moderate and severe food insecure respectively.

In VDM, for households involved as small-scale fisheries, 2% and 98% have low dietary diversity and high dietary diversity respectively while, 59%, 7%, 24% and 10% of the sampled households reported to be food secure, mildly, moderate and severe food insecure respectively. From subsistence fishers point of view, 13% and 87% of the households have low dietary diversity and high dietary diversity respectively. Moreover, 63% and 37% of the households reported being food secure and severe food insecure respectively. None of the small-scale fishers reported to be mildly and moderately food insecure. Only 3 of the households (who represent 100%) involved in recreational fishing in VDM have high dietary diversity. Thus, 95% do not participate in recreational fishing. Approxiaelty, about 67% are food secure and the remaining 3% are severy food insecure. These households are also small-scale fishers who also participate in inland fisheries as recreational fishers.

About 4% and 96% of non-fishing households have low dietary diversity and high dietary diversity respectively. Although the majority of the households not involved in inland fisheries reported being food secure (49%), about 7%, 14% and 30% households reported to be mildly, moderately and severe food insecure respectively. The Pearson Chi-square probabilities of 0.001 for SDM (significant level 1%), 0.056 for MDM (significant level 10%), and 0.055 for VDM (significant level 10%)indicate that the food security situation of fishing and non-fishing households differs. In comparison to non-fishing households, households that engage in fisheries may have more money to purchase a variety of food to meet their daily supply. Furthermore, it is possible that this is based on the availability of fish for consumption or income. Furthermore, the findings suggest that the households in the study area may not be in the same income groups; thus, some households may have diversified

their income while others rely solely on government assistance or agriculture. This then explains the difference in the food security.

4.9.2. Average Household Dietary Diversity (HDDS) and Household food insecurity access scales (HFIAS)

As a qualitative measure of food consumption which reflects the access of households to various foods, the average HDDS for the households in SDM, MDM and VDM was calculated for both households involved in inland fisheries and those not involved. The results are presented in Table 4.16.

Table 4.16: Average HDDS and HFIAS

HDDS	
District	Average
SDM	9.83
MDM	10.19
VDM	9.43
HFIAS	
District	Average
SDM	5.68
MDM	14.66
VDM	6.44

Source: Survey results (2021)

Two mutually exclusive levels have been used to group the HDDS scores, that is High Dietary Diversity (HDD) and Low Dietary Diversity (LDD). A Dietary Diversity of 0-5 shows LDD, where else a score of 6-12 indicates HDD.

The results presented in Table 4.16 shows that the average HDDS for households in SDM, MDM and VDM is 9.83, 10.19 and 9.43 respectively. This shows that the dietary diversity situation for the households in the three studied districts is normal implying that these households have a high dietary diversity. This means that the households in SDM, MDM and VDM consume various food groups hence the diets are diverse. However, De Cock *et al.,* (2013) found that the average HDDS in the Limpopo Province is 4.57 suggesting that most households in the province have low dietary diversity. Moreover, Bulletin (2017) states that fishing and farming households have low access to food groups with 23% of the surveyed samples consuming about four or fewer food groups. On the contrary, a study by

O'Meara *et al.,* (2021) found that children who consumed fish from nearby inland waters had high dietary diversity.

On the other hand, the average HFIAS scores were also calculated for households in SDM, MDM and VDM. The study found that the average HFIAS for households in SDM, MDM and VDM is 5.68, 14.66 and 6.44 respectively. Following Chakona and Shackleton (2018), the HFIAS score ranging from 0-27 are grouped into four were, 0-1 categorises households as food secure. A score of 2-7, 8-11 and greater than 11 is categorised as mildly, moderately, and severely food insecure households respectively. Therefore, the results presented show the average HFIAS in all three district municipalities. Therefore, the results imply that households in SDM and VDM are mildly food insecure. However, the results show that households in MDM are severely food insecure. These findings agree with De Cock *et al.,* (2013) who found that majority of households in the Mopani District Municipality are severely food insecure.

4.10. Consumption pattern of fish consumed by households involved in inland fisheries and those not involved.

The following section presents the consumption pattern of fish by households involved in inland fisheries and those not involved. The presented findings show how many households mentioned how often they consume certain fish in a week. The results are grouped based on the district municipality, that is, SDM, MDM and VDM. Both fish from the inland fisheries and stores are also presented in this section.

4.10.1. Consumption pattern of inland fish by households in SDM

The consumption pattern of fish for households in SDM are presented in Table 4.17. As noticeable from the results, the majority of the households in SDM consume tin/canned fish which is normally bought at the nearest local stores. Usually, this type of fish is consumed once a week (mentioned by 40 households). About 31 and 38 of the households mentioned that in the last 7 days, they have eaten Catfish and Tilapia once respectively. About 12, 6, 1, 21 and 22 mentioned that Tuna, Bass, Eel, Carp and was consumed once in the last seven days respectively. The majority of the households in the study area also consume fish twice a week with Tilapia leading as the most consumed fish.

Table 4.17: Consumption pattern of inland fish by households in SDM

No. t/w	Tun.	Catf	Til.	Bass	Tro.	Eel	Tig.	Carp	Tin fish	Hake	Other
Once a week	12	31	38	6	0	1	0	21	40	22	0
2/ week	0	11	30	1	0	0	0	15	23	10	0
3 /week	0	9	7	0	0	0	0	14	13	3	0
4 /week	0	0	3	0	0	0	0	4	3	0	0
5 / week	0	0	0	0	0	0	0	2	0	0	0
6 / week	0	0	0	0	0	0	0	1	0	0	0
Whole week	0	0	0	0	0	0	0	0	0	0	0

Where: No.t/w = number of times per week, Tun.= Tuna, Catf.=Catfish, Til.= Tilapia, Bass=Bass, Tro.=Troat, Eel=Eel, Tig.=Tigerfish, Tin fish= Tin fish/canned fish, Hake=Hake
Source: Survey results (2021)

By evaluating the results in Table 4.17, it is shown that Catfish, Tilapia, Carp, tin fish and Hake are mostly consumed at least three times a week. For instance, about 9, 7, 14, 13 and 3 households mentioned that in the last seven days, they have consumed Catfish, Tilapia, Carp, canned fish and Hake respectively. Only 3, 4, 3 of the households mentioned that they have consumed fish at least four times a week. Additionally, only 2 and 1 households mentioned that for the past seven days, they have eaten tin fish 5 and 6 times. None of the households has eaten any type of fish for the whole seven days. Therefore, it can be mentioned that inland fish species such as Catfish, Tilapia, Bass and Carp are consumed at least once a week in SDM.

4.10.2. Consumption pattern of inland fish by households in MDM

The results presented in Table 4.18 show the consumption pattern of fish by households in MDM. As evident from the results, the majority of the households consume tin/canned fish followed by Bass, Tilapia, other fish types, Catfish, Carp and Hake. Tuna, Eel and Tigerfish were consumed by 1 (for both tuna and eel) and 3 households once during the week respectively. Tilapia is the common inland fish consumed by most households in the study area and was consumed for the whole week by 17 households, where else 4 and 8 households also mentioned that they consume tin fish and other types of fish [specifically maasbanker (*Trachurus capensis*)]. Tuna was consumed once and two times a week by 1

and 5 households respectively. Similarly, Catfish, Tilapia, Bass, Trout, Carp, tin fish, Hake and other types of fish were consumed twice a week by 2, 10, 16, 2, 1, 10, 15 and 4 households respectively.

Table 4.18: Consumption pattern of inland fish by households in MDM

No. t/w	Tun.	Catf	Til.	Bass	Tro.	Eel	Tig.	Carp	Tin fish	Hake	Other
Once a week	1	10	19	22	0	1	3	10	32	9	16
2/week	5	2	10	16	2	0	0	1	10	15	4
3 /week	0	1	9	1	0	0	0	0	7	2	8
4 /week	0	0	8	0	0	0	0	5	5	1	4
5 / week	0	1	6	2	1	0	0	0	0	0	4
6 / week	0	0	0	0	0	0	0	0	0	2	2
Whole week	0	0	17	0	0	0	0	0	4	0	8

Where: No.t/w = number of times per week, Tun.= Tuna, Catf.=Catfish, Til.= Tilapia, Bass=Bass, Tro.=Troat, Eel=Eel, Tig.=Tigerfish, Tin fish= Tin fish/canned fish, Hake=Hake
Source: Survey results (2021)

Inland fishes such as Catfish, Tilapia and Bass were consumed by 1, 9 and 1 households three times a week as indicated in Table 4.18. On the other hand, 8, 5, 5, 1 and 4 households have consumed Tilapia, Carp, tin fish, Hake and other types of fish five times a week. Only 1, 6, 2, 1 and 4 of the households consumed Catfish, Tilapia, Bass, Trout and other types of fish five times a week respectively. As for the consumption of fish six times a week, only 2 households mentioned that they consumed Hake and other types of fish. To this end, fish is consumed at least once a week in the study area. However, the consumption of fish differs by species, availability, and affordability. Moreover, it is recommended that households eat fish at least twice a week so to acquire nutrients from the fish (Vilain and Baran, 2016).

4.10.3. Consumption pattern of inland fish by households in VDM

From the results presented in Table 4.19, the majority of the household in VDM consume fish (either from a store or harvested within inland waters) at least once a week. For instance, only 1 household mentioned that they have consumed tuna once in the last seven days while, Catfish, Tilapia, Bass, Trout, Tigerfish, Carp, tin fish and Hake were also consumed 15, 30, 7, 3, 6, 24 and 6. These results suggest that Tilapia is the most prefer inland to fish for consumption by households in VDM. As seen from the results emanating from Table

4.19, only 1 household mentioned that they have consumed fish for the whole week. The fish in question is Tilapia.

Table 4.19: Consumption pattern of inland fish by households in VDM

No. t/w	Tun.	Catf.	Til.	Bass	Tro.	Eel	Tig.	Carp	Tin fish	Hake	Other
Once a week	1	15	30	7	0	0	3	6	24	6	0
2/week	4	6	11	1	0	0	2	3	21	7	0
3 /week	1	3	9	0	0	0	0	3	3	2	0
4 /week	4	0	4	0	0	0	0	0	1	1	0
5 / week	0	0	0	0	0	0	0	0	0	0	0
6 / week	0	0	0	0	0	0	0	0	1	0	0
Whole week	0	0	1	0	0	0	0	0	0	0	0

Where: No.t/w = number of times per week, Tun.= Tuna, Catf.=Catfish, Til.= Tilapia, Bass=Bass, Tro.=Troat, Eel=Eel, Tig.=Tigerfish, Tin fish= Tin fish/canned fish, Hake=Hake
Source: Survey results (2021)

Likewise, only 3, 9 and 3 of inland fish species were consumed three times a week as indicated in Table 4.19. These fish species are Catfish, Tilapia and Carp respectively. Few of the households mentioned that they have consumed Tuna, Tilapia, tin fish and Hake at least four times a week. Also, about 6, 11, 1, 2 and 3 of the households have eaten Catfish, Tilapia, Bass, Tigerfish and Carp at least twice a week respectively. These results confirm that inland fisheries contribute to the dietary diversity of households. Therefore, the study agrees with the previous literature which suggests that inland fisheries contribute to household food security (Tapela *et al.,* 2015; Britz *et al.,* 2015; FAO, 2018a; Funge-Smith and Bennett, 2019).

4.11. Logistic model fit results for determinants of rural households' dietary diversity in SDM, MDM and VDM

The logistic results presented in Table 4.20 shows -2log likelihood of SDM, MDM and VDM as 30.77, 65.03 and 36.10 respectively. The main assumption for the -2log likelihood ratio is that there are determinants of rural households' dietary diversity in the Limpopo Province. The results presented the Cox and Snell of 17.4%, 16.8% and 9.1% in SDM, MDM and VDM

respectively. On the other hand, Nagelkerke R square resulted in 47.3%, 34.5% and 31.6% in SDM, MDM and VDM respectively. The Nagelkerke results imply that 47.3%, 34.5% and 31.6% of the predictors in SDM, MDM and VDM are respectively explained by the model.

Cox and Snell compare the loglikelihood for the model with that of the baseline model which is an indication of the external variance in the outcome variance expanded by the model. The Cox and Snell cannot reach a maximum likelihood of 1. Nagelkerke on the other hand is an adjusted Cox and Snell for the maximum value so that it can reach 1 however, it ranges from 0 to 1. Therefore, the Nagelkerke is considered as a better measure than the Cox and Snell (Agyei, 2016). To obtain the logistic regression results, a stepwise regression analysis was carried out for all the districts.

The Chi-squared of 21.98 in SDM with a probability value of 0.056 means that there is a significant relationship between the independent variables and the dependent variable. The results presented a Chi-square of 24.70 with a probability value of 0.038 in MDM. On the other hand, the Chi-square of 14.12 with a probability value of 0.079 in VDM is also presented in Table 4.20. These results imply that there is a significant relationship between the independent variables and the dependent variable. All the results presented in Table 4.20 imply that the model is fit.

Table 4.20: Logistic model fit results for SDM, MDM and VDM

Category	SDM	MDM	VDM
-2 Log Likelihood	30.77	65.03	36.10
Cox and Snell R Square	17.4%	16.8%	9.1%
Nagelkerke R Square	47.3%	34.5%	31.6%
Model Chi-square	21.98	24.70	14.12
Model significance	0.056	0.038	0.079

Source: Survey results (2021)

4.11.1. Binary logistic results for SDM

Table 4.21 depicts the binary logistic regression results of the study in SDM. The study included thirteen independent variables but only five of the thirteen independent variables were found to be significant. From the five identified significant variables, four variables were found to be positively significant and only one variable is negatively significant. The positively and statistically significant variables are access to credit, access to the market, distance to fishing area and type of inland fisheries the household is involved in. The

negatively significant variable is identified as a number of years the household has been involved in fisheries.

Table 4.21: Binary logistic results for SDM.

Variables	B	S.E.	Wald	Sig.
Constant	-15.438	7.842	3.876	.049
Age of household head	.002	.037	.003	.955
Number of household members	.108	.287	.142	.706
Level of education	.504	.623	.655	.418
Access to credit	3.535	1.846	3.669	.055*
Access to market	3.423	1.415	5.855	.016**
Distance to market	2.428	2.054	1.397	.237
Number of years fishing	-.419	.220	3.613	.057*
Distance to fishing area	.610	.320	3.641	.056*
Reason for fishing	-.594	.509	1.359	.244
Type of agricultural activity	-.040	1.067	.001	.970
Source of household head income	-.095	.155	.376	.540
Average price of fish	.027	.043	.405	.524
Type of inland fish involve in	6.850	4.131	2.749	.097*

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Access to credit

The variable access to credit was found to be positively and statistically significant at a 10% level with a coefficient of 3.535. The results imply that access to credit has a positive relationship with the household dietary diversity of fishing and non-fishing households in the Limpopo Province. This suggests that the more the household have access to credit, the more they can diversify their diets through the purchasing of different food groups. Moreover, these households can be able to purchase fish from inland waters and from retail shops. According to Annim and Frempong (2018), having access to credit helps improve the dietary diversity of households' because they consume a more diversified diet. Therefore, having both formal and informal access to credit can assist households to achieve this goal (Biyase and Fisher, 2017).

b) Access to market

The study revealed market access to be positive and significant at 5% implying a significant relationship with household dietary diversity. The coefficient of access to the market is positively associated with household dietary diversity. These results suggest that having market access is likely to increase the dietary diversity of households. Sibhatu *et al.,* (2015); Qaim *et al.,* (2016) also found market access to have a positive effect on dietary diversity.

c) Distance to the fishing area

Regarding distance to the fishing area, the binary logistic results presented the variable positively and statistically significant with household dietary diversity. The results suggest that having a long distance to the fishing area is likely to increase the dietary diversity of households. The ability of households to access the fishing resources might allow them to catch fish either for consumption or for sale thus increasing the household dietary diversity. However, a long-distance might reduce the households' ability to do so due to high transportation costs.

Moreover, since fish is easily perishable, for poor households who lack resources to preserve the fish until it reaches the market, a short distance will mean that the fish can still be of good quality upon reaching the market. Alva *et al.,* (2016) found a positive relationship between Marine Protected Area (MPA) and children dietary diversity when the MPA is located closer than 2km to where the community in which the child lives is located. This suggests that when the distance travelled to the MPA is short, the dietary diversity of children residing closer to the MPA might increase due to the availability and consumption of fish.

d) Number of years fishing

Several years of fishing which is the experience that households have in fishing were found to be negatively and statistically significant with household dietary diversity. Chan *et al.,* (2019) explain that fishing experience is important in fisher's perception of fish abundance which in turn allows households to continuously increase their dietary diversity. Although experience is acquired over time, the results in this study suggest that fishing experience reduces the dietary diversity of households. This was rather unexpected however the negative sign may imply that the less experienced the household has in fishing the less their dietary diversity. This might be true for households with low income and have low dietary diversity.

e) Type of inland fisheries

The variable type of inland fisheries involved resulted in a positive and statistically significant variable at a 10% level. This suggests that there is a significant association between the type of inland fisheries that the household is involved in and their dietary diversity. For instance, when households are involved in inland fishing, they can consume fish and also sell to generate income to purchase other food items thus increasing their dietary diversity. Moreover, Britz *et al.,* (2015); Tapela *et al.,* (2015); Bennett *et al.,* (2018) states that inland fisheries contribute to both food security and dietary diversity of households.

4.11.2. Binary logistic results for MDM

Table 4.22 depicts the binary logistic regression results of Mopani District Municipality (MDM). A stepwise regression analysis was employed, and fourteen independent variables were included. The results show that three of the fourteen independent variables were found to be significant. From the three identified significant variables, one variable was found to be positively significant, and two variables are negatively significant. The positively and statistically significant variable is level of education of the household head. The negative variable includes distance to the market and source of income.

Table 4.22: Binary logistic results for MDM.

Variables	B	S.E.	Wald	Sig.
Constant	1.102	4.200	.069	.793
Gender of household head	1.198	.856	1.958	.162
Number of household members	.121	.179	.458	.498
Total household income	.000	.000	.810	.368
Marital status	.353	.398	.784	.376
Level of education	.972	.466	4.343	.037**
Access to credit	-.673	1.306	.265	.607
Distance to the market	-.271	.158	2.960	.085*
Type of inland fish involve in	-1.667	1.218	1.874	.171
Distance to the fishing area	-.019	.023	.689	.407
Average price of fish	.005	.014	.147	.701
Quantity of fish sold per season	-.007	.005	2.283	.131
Reason for fishing	.095	.183	.271	.603
Type of agricultural activity	.417	.365	1.302	.254

Source of household head income	-.113	.066	2.936	.087*

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Level of education

The binary logistic results indicated that the level of education is positively and statistically significant at a 5% level. This suggests that there is a relationship between the level of education of the household head and dietary diversity. When the household head is educated, they are likely to make a better decision in purchasing food items that will benefit the health of the household. Thus, including fish in the menu is likely to improve the diets of people residing in the household. According to Bortha (2010), the education level of the household head is inversely related to household poverty. This suggests that when the household head is educated, the likelihood of the household being poor is low. Thus, education is important for improving the dietary diversity of the household. *Legbara (2019)* also states that education is important in reducing poverty, and it is part of human development. These results concur with the studies conducted by Codjoe *et al.,* (2016) who found education to be significant with household dietary diversity and that educated households have a higher dietary diversity as compared to uneducated households.

Additionally, Codjoe *et al.,* (2016); Legbara (2019) emphasise that education provides the household head with knowledge on the nutritional benefits of a balanced diet. The household head in this case can also know the importance of adding fish from inland waters since it provides more nutritional benefits as compared to farmed fish. Similar comparable findings were also identified by Taruvinga *et al.,* (2013).

b) Distance to market

The variable distance to market was found to be negatively and statistically significant with household dietary diversity. These results suggest that there is an inverse relationship between distance travel to the market to purchase food items and the dietary diversity of households. For instance, the results imply that an additional kilometre of distance travelled might decrease household dietary diversity. This suggests that the further the market is, the more the dietary diversity of households is likely to decrease. This can be due to transport costs, poor road infrastructure and climate conditions especially when purchasing inland fish due to its easy perishability. If the distance to the market is longer, households are likely to travel there occasionally. Therefore, the further the distance to the market, the lower the

dietary diversity. On the other hand, Nandi *et al.,* (2021) found that reduced distance to the market contributes to higher dietary diversity. Therefore, households that are closer to the market have a higher dietary diversity as compared to those further to the market. Moreover, this may propose that households with diverse diets are likely to travel further to purchase the different food items.

c) Source of household head income

The Source of income of the household head was found to be negatively significant at a 10% level of significance. The results suggest that an additional source of income will reduce household dietary diversity. This might be that the more sources of income the household has, they might invest more money in other luxury resources other than food. Although an additional source of income is likely to boost household food expenditure, evidence from studies such as those from Fanzo (2017); Nkegbe *et al.,* (2017) indicate that the improvement of household income does not mean improvement to household diets.

4.11.3. Binary logistic results for VDM

Table 4.23. represents the binary logistic regression results of Vhembe District Municipality (VDM). A stepwise regression analysis was employed, and eight independent variables were included in the regression. The results show that four of the eight independent variables were found to be significant. These variables are the marital status of household head, the average quantity of fish sold per season, number of fishing labours and number of years fishing.

Table 4.23: Binary logistic results for VDM

Variables	B	S.E.	Wald	Sig.
Constant	6.139	2.227	7.602	.006
Age of household head	.049	.042	1.340	.247
Total household income	.001	.000	1.403	.236
Marital status	-.915	.461	3.944	.047**
Distance to fishing area	-.171	.115	2.212	.137
Source of household head income	-.073	.102	.516	.472
Average quantity of fish sold per season	-.007	.003	4.591	.032**
Fish labourers hired	.492	.222	4.895	.027**
Number of years fishing	-.274	.161	2.908	.088*

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Marital status

The variable marital status was found to be negatively and statistically significant with dietary diversity at a 5% level of significance. This implies that the marital status of households might decreases the dietary diversity. According to Liu *et al.,* (2014), married households tend to consume a greater variety of food. This is because of the high number of household members within married households thus desiring different types of foods. Moreover, larger households tend to consume more food items. Likewise, these results may suggest that being married is not an assurance for a high dietary diversity, however, a household head that is married may get support from their spouse who is employed and able to assist with the purchase of various food items.

b) Average quantity of fish sold per season

The quantity of fish sold per season was found to be negatively and statistically significant at a 5% level of significance. This implies that there is an inverse relationship between the number of fish sold per season and household dietary diversity. The results suggest that if the quantity of fish that a household catch decreases, the household is likely to have low dietary diversity. This is because if the number of fish that households sell decreases, the household might not generate enough income to purchase diverse food for the household. Having no access to close large rivers decreases the consumption of fresh fish which affects the income generation and also the dietary diversity (Dlamini, 2013).

c) Fishing labourers

The variable fishing labours was found to be to be positively and statistically significant at a 5% level of significance. This indicates that there is a direct relationship between fishing labours that households employ and the dietary diversity of households. For instance, if households employ additional labour, they are likely to harvest more fish that can be sold to generate income. According to Kloss and Martin (2018), hired labour is more productive than family labour. These might be that hired labour receive financial benefits for the job done as compared to family labour. Moreover, family labour is slowly becoming unsustainable (Okoye *et al.,* 2015). However, a previous study by Onumah *et al.,* (2010) found that both hired, and family labour is equally productive in fish farming.

d) Number of years fishing

The variable number of years employed is negative and statistically significant at a 10% level of significance. The implication, in this case, is that an increase in the number of years in fishing/experience in fishing is likely to decrease the dietary diversity of households. This means that households with more years in fishing are likely to have a low dietary diversity compared to those with few years. This might be true if the household has been fishing for a long time and they only rely on fish as a source of income. Due to the variation of climatic conditions, the household is likely not to get the same quantity of fish in every fishing trip. Households who have just started participating in fishing activities are likely to have an additional source of income where they can still purchase food for their households. Moreover, the households with few years in fishing may have less experience with catching fish and they may catch fewer fish as compared to those who have been fishing for a longer time. According to Mvula (2009), increased experience in fishing enables fishers to access new technology and information and assist farmers in choosing the appropriate fishing location. This will then enable the household to increase the quantity of fish that households catch either for consumption or for generating income. In the end, the household dietary diversity will increase.

4.12. Multicollinearity results for SDM, MDM and VDM

Multinomial Logistic regression analysis was used to determine the effects of inland fisheries on household food security in the Limpopo Province. Firstly, a multicollinearity test was done on the variables for each of the district municipalities. Variance Inflation Factor (VIF) was then employed to test for the presence of multicollinearity. The VIF identifies collinearity between the independent variables and the strength of that correlation. The VIF observations with a value of 1 have little multicollinearity where else values above 5 are considered to be strongly correlated (Sgro *et al.,* 2019). The overall VIF for SDM is 1.597. On the other hand, the average VIF for MDM and VDM is 1.871 and 1.912 respectively. These results imply that the fitted variables do not exhibit multicollinearity.

A collinearity test was carried-out and the results indicate that the variables did not exhibit multicollinearity as observed in Table 4.24. Therefore, non-collinearity assumptions were then satisfied, and the model was estimated.

Table 4.24: Multicollinearity results for SDM, MDM and VDM

	SDM		MDM		VDM	
Variables	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Age of household head	.795	1.258	.711	1.406	.617	1.620
Gender of household head	.769	1.301	.893	1.119	.645	1.549
Number of household members	.747	1.338	.924	1.082	.757	1.321
Total household income	.626	1.599	.928	1.078	.734	1.363
Marital status	.810	1.234	.784	1.275	.723	1.383
Level of education	.894	1.119	.871	1.148	.670	1.493
Distance to market	.913	1.096	.261	3.836	.914	1.094
Reason for fishing	.319	3.132	.350	2.854	.249	4.022
Type of agricultural activity	.911	1.098	.938	1.066	.800	1.251
Source of household head income	.804	1.244	.864	1.157	.735	1.360
Distance to the fishing area	.317	3.154	.219	4.564	.219	4.573
Average VIF		1.597		1.871		1.912

Source: Survey results (2021)

4.13. Multinomial Logistic regression (MLR) model fit results

Table 4.25 presents the model fit results obtained from Multinomial Logistic regression which was analysed using STATA Version 15. The results presented are for Sekhukhune District Municipality (SDM) with a sample size of 115, Mopani District Municipality (SDM) with a sample size of 134 and Vhembe District Municipality (VDM) with a sample size of 151.

Model fitting results presented the results for -2Log Likelihood, Log-Likelihood Chi-square, probability Chi-square and the Pseudo R^2 for all the three district municipalities studied. For instance, Sekhukhune, Mopani and Vhembe District Municipalities presented a -2Log Likelihood of -124.324, -106.324, and -144.910 respectively. The -2Log Likelihood is used to test whether all coefficients of the predictors in the model are simultaneously zero.

The Chi-square of the likelihood is also presented in Table 4.25. The results show that the model is fit for all the districts with probability Chi-square represented at 1% significance. The probability Chi-square, in this case, indicates that at least one of the regression coefficients in the model is not equal to zero. This is indicated by the probability Chi-square results of Sekhukhune (0.0043), Mopani (0.0001) and Vhembe (0.0019) with a Chi-square of 54.22, 70.97 and 57.46 respectively. The log-likelihood Chi-square and the probabilities suggest that the model fits more significantly than an empty model. The results of the Pseudo R^2 are also presented in Table 4.25. For SDM the Pseudo R^2 is 0.1897 and for MDM is 0.2502. For VDM, the Pseudo R^2 is 0.1654.

Table 4.25: Model fit results for MLR in SDM, MDM and VDM

District	N	-2Log Likelihood	-2Log Likelihood Chi-square	Probability Chi-square	Pseudo R^2
SDM	115	-124.324	54.22	0.0043	0.1897
MDM	134	-106.324	70.97	0.0001	0.2502
VDM	151	-144.910	57.46	0.0019	0.1654

Source: Survey results (2021)

In the interest of determining the effects of inland fisheries on household food security status, the multinomial logistic regression was employed. The dependent variable (food security status) has four outcomes. The first outcome is food security, followed by mildly food insecurity. Outcome three and four are moderate food insecure and severe food insecure respectively. Outcome one (food secure) was used as the base (reference/category) outcome. Due to the difficulty of interpreting coefficients of MLR, the marginal effects are then used to interpret the effects of the explanatory variables on the probabilities (Greene, 2002). Therefore, the results of MLR in this study are interpreted such that if the dependent variable has a positive sign, that means the other outcome is more likely to be chosen than the base/reference outcome (Obi, 2011; Cheteni and Mokhele, 2019; Christian *et al.,* 2020).

4.13.1 Multinomial logistic results for the SDM

The Multinomial logistic results for the SDM are presented in Table 4.26. The results show that out of eleven variables concerning mildly food security, only five variables were found to be significant, while three variables were found to be significant with moderately food insecure and, one variable is significant with severe food insecurity. These variables mildly food security under mildly food insecure includes gender of the household head, number of household members, total household income, marital status and level of education. Variables significant under moderately food insecure are, number of household members, level of education and type of agricultural activity. Marital status is significant with severe food insecurity. The Delta method was used to obtain the marginal effects for the MLR.

Table 4.26. Multinomial logistic results for the SDM

Variables	dy/dx	Std. Error	Z	P>|z|
Mildly food insecure				
Age of household head	-.003	.003	-0.88	0.378
Gender of household head	-.207	.101	-2.06	0.040**
Number of household members	-.035	.019	-1.80	0.072*
Total household income	.000	6.37e-06	1.99	0.046**
Marital status	-.131	.056	-2.32	0.021**
Level of education	.075	.034	2.22	0.026**
Distance to market	.063	.063	1.00	0.319
Reason for fishing	-.024	.022	1.10	0.272
Type of agricultural activity	-.019	.059	-0.33	0.741
Source of household head income	-.009	.009	-0.96	0.335
Distance to fishing area	-.000	.001	-0.35	0.725
Moderate food insecure				
Age of household head	.0020	.003	0.74	0.457
Gender of household head	-.0652	.082	-0.80	0.425
Number of household members	.0313	.016	1.97	0.049**
Total household income	- 6.70e-06	6.97e-06	-0.96	0.337
Marital status	-.009	.040	-0.22	0.828
Level of education	-.059	.036	-1.66	0.097*
Distance to market	.0063	.061	0.10	0.918

Reason for fishing	.029	.019	1.55	0.120
Type of agricultural activity	.121	.063	1.93	0.054**
Source of household head income	.011	.008	1.41	0.157
Distance to fishing area	.001	.001	0.70	0.485
Severe food insecure				
Age of household head	-.000	.0023	-0.19	0.851
Gender of household head	.0711	.066	1.08	0.282
Number of household members	.014	.014	1.02	0.309
Total household income	-.000	8.06e-06	-1.59	0.113
Marital status	.04	.026	1.69	0.090*
Level of education	-.018	.028	-0.65	0.513
Distance to market	-.106	.072	-1.48	0.139
Reason for fishing	-.013	.019	-0.63	0.528
Type of agricultural activity	-.055	.041	-1.33	0.185
Source of household head income	-.006	.007	-0.78	0.433
Distance to fishing area	-.001	.001	-0.72	0.469

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Gender of the household head

Gender of the household head (1 male, 0 otherwise) resulted in a negatively and statistically significant when comparing mildly food insecure to food secure. The results suggest that compared to those who were food secured, being a male headed household increased the probability of being mildly food insecure by 0.03%. Sakyi (2012) found that male-headed households receive more remittances, salaries or wages and are more actively involved in agricultural activities compared to females. This explains the reason households headed by males are likely to be food secure compared to female-headed households. Ndobo *et al.,* (2013); Tibesigwa and Visser (2016); Abdullah *et al.,* (2019); Nagesse *et al.,* (2020) found that female-headed households are more food insecure compared to male-headed households. According to Kuwornu *et al.,* (2013); households headed by females tend to have a high dependency ratio which is likely to increase food insecurity.

b) Number of household members

According to the results presented in Table 4.26, having several household members appear to be negatively correlated with mildly food insecure and positively correlated with moderately food insecure at 5%. The likelihood of households being food secure increases by 0.35% when the household size decreases. Household members who relocate to other places reduce the food insecurity situation of that households. Moreover, having an additional household member is likely to render the household moderately food insecure. A larger household size requires more food than a smaller household thus increasing the likelihood of being food insecure (Lutamia *et al.,* 2019; Himi *et al.,* 2020). Jeyarajah (2018) attests that household size is an important socio-economic indicator as it affects household income and food security.

c) Total household income

Total household income presents a positive relation with mildly food insecurity at a 5% level relative to the reference category. The marginal effects for mild food insecurity suggest that for every R1 increase in household income, there is a 0.01% of becoming mildly food insecure. Kuwornu *et al.,* (2013) also found similar results. Likewise, having additional income from inland fisheries activities is likely to boost household income.

d) Marital status

The MLR results for the variable marital status was found to be negatively significant with mildly food insecure and positively significant with severe food insecure. The marginal effects suggest that when the household head is married, the likelihood of being food secure increases than a household head who is not married. The results further imply that a household head who is married and engages in inland fisheries is likely to be food secure compared to an unmarried household head who does not engage in inland fisheries. This is because the household head who is married and engages in inland fisheries has the responsibility of feeding the family. Thus, inland fisheries bring an opportunity for the household to be food secure. Moreover, married households can engage in fishing together. For instance, Pizzali (2001) found that fishing is mostly a family affair where both husband and wife engage in fishing activities to generate income and for food security. The results are contrary to the findings of Akukwe (2020) who found that households that are unmarried are more likely to be food secure than those households headed by married people.

e) Level of education

The variable level of education was found to be positively and statistically significant at a 5% level with mildly food insecure and negatively significant with moderately food insecure (at 10%). The marginal effects suggest that the more the household head is educated, there is a 0.75% chance that the household food insecurity status might be mild. However, when households get more education, the food security status might increase. That is to say, the household is likely to be food secure. Kara and Kithu (2020) found a positive relationship between the attainment of education by the household head and the food security status of the household. The results revealed that the more education the household head gets, the more the food security situation of the household improves. This is because, when the household head is educated, the likelihood of engaging in inland fisheries also increases. After all, it might be easier to acquire information about the benefits of inland fisheries for food security. Moreover, education is an important aspect of promoting the capacity of the rural poor so to escape from poverty and hunger with their power (Kara and Kithu, 2020). Akukwe (2020) also found that education increases the likelihood of households being food secure.

f) Type of agricultural activity

The type of agricultural activity that households are involved in was found to be positively and statistically significant. The results revealed that there is a positive correlation between the variable and moderate food insecurity status. These results suggest that households involved in agriculture are likely to be moderately food insecure relative to the reference category. The marginal effects suggest that food security increases by 0.12 units when the household is involved in agricultural activities. Agriculture is viewed as a sector that contributes to nutrition, employment and food security at the household level (Modi, 2018). Therefore, agriculture serves as one of the risk management strategies for inland fisheries when the household has caught less fish. Thus, like agriculture, fishing is a risky business (Kasperski and Holland, 2012; Mokhaukhau *et al.,* 2020).

4.13.2. Multinomial logistic results for the MDM

The Multinomial logistic results for the MDM are presented in Table 4.27 The results show that out of eleven variables concerning mildly food security, only three variables were found to be significant. These variables are Total household income (positively significant), distance to the market (positively significant) and source of household head income

(positively significant). Moreover, total household income is positively significant with moderately food insecure while, it is negatively significant with severe food insecurity. Adding to this, distance to the market is negatively significant at a 5% level with severe food insecurity. Type of agricultural activity is positively significant at 10% level with severe food insecurity. The Delta method was also used to obtain the marginal effects for the MLR.

Table 4.27: Multinomial logistic results for the MDM

Variables	dy/dx	Std. Error	Z	P>|z|
Mildly food insecure				
Age of household head	.001	.002	-0.79	0.427
Gender of household head	.035	.059	0.59	0.553
Number of household members	-.017	.016	-1.07	0.283
Total household income	.000	5.62e-06	3.58	0.000***
Marital status	-.000	.032	-0.01	0.992
Level of education	.023	.027	0.85	0.398
Distance to market	.028	.012	2.31	0.021**
Reason for fishing	-.011	.014	-0.78	0.437
Type of agricultural activity	-.022	.030	-0.74	0.460
Source of household head income	.008	.004	2.06	0.039**
Distance to fishing area	-.001	.001	-0.67	0.506
Moderate food insecure				
Age of household head	.003	.003	1.01	0.313
Gender of household head	.041	.072	0.57	0.565
Number of household members	.005	.018	0.26	0.797
Total household income	.000	8.36e-06	2.45	0.014 **
Marital status	-.007	.039	-0.17	0.863
Level of education	.019	.032	0.60	0.547
Distance to market	.013	.015	0.88	0.377
Reason for fishing	-.000	.018	-0.02	0.988
Type of agricultural activity	-.084	.035	-2.39	0.017**
Source of household head income	-.001	.006	-0.12	0.907
Distance to fishing area	-.000	.001	-0.07	0.943
Severe food insecurity				
Age of household head	-.002	.003	-0.81	0.419

Gender of household head	-.058	.072	-0.81	0.419
Number of household members	.025	.018	1.36	0.175
Total household income	-.000	.000	-3.76	0.000***
Marital status	-.011	.040	-0.28	0.778
Level of education	-.038	.032	-1.18	0.237
Distance to market	-.034	.015	-2.25	0.024**
Reason for fishing	-.001	.006	-0.12	0.907
Type of agricultural activity	.069	.039	1.76	0.079*
Source of household head income	-.009	.005	-1.64	0.101
Distance to fishing area	.001	.001	0.77	0.439

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Total household income

The variable total household income was found to be positively and statistically significant with mildly food insecure and moderately food insecure. However, the variable is negatively significant with severe food insecurity. The marginal effects under mildly and moderately food insecure suggests that an R1 increase in total household income is likely to render the household to be mildly and moderately food insecure. Contrary to that, an increase in the total household income might increase the chances of the household being food secure. Himi *et al.,* (2020) states that households with low monthly income tend to be food insecure compared to households with more monthly income. These, results might imply that the probability of an increase in R1 on the household income increases when the household is engaged in inland fisheries and decreases when the household is not involved. Thus, total household income influences the food security status of households both involved and not involved in inland fisheries however, these effects differ.

b) Distance to the market

Distance to the market was found to be positively and statistically significant at a 5% level with mildly food insecure and negatively significant with severe food insecurity. The results of the marginal effects suggest that holding other things constant, the likelihood of households being mildly food insecure increases as distance to the market increases by 0.028km. However, the negative coefficient under severe food insecurity suggests that when the distance to the market is short, households are likely to be food secure. Therefore,

improved road infrastructure and the type of transport used to access the market plays an important role in food security.

However, an increase in distance to the market results in a negative relationship with food security. These results imply that households who sell the fish in the market (either formal or informal), have a higher chance of being food secure if the distance is short since fish is perishable. For households who purchase fish at the market, the likelihood of being food secure decreases when the distance increases. This is because the distance travelled to the market influences whether the household will purchase fish or not due to its perishability.

c) Source of household income

The source of income was found to be positively and statistically significant at a 5% level of significance with mildly food insecure. The marginal effects imply that an additional source of income for the household might render the household mildly food insecure by 0.8% relative to the reference category. This is because of the total income and the different sources that households have.

d) Type of agricultural activity

Type of agricultural activity was found to be positively and statistically significant at the 10% level with severe food insecurity. The marginal effects suggest that being involved in agriculture might increase the food security status of the household by 0.08 units. The positive sign under severe food insecurity suggests that agriculture is likely to lead the household to be severely food insecure. These might be due to the riskiness of agriculture that is brought by climatic conditions, pest attacks, crop failure and market uncertainty (Mokhaukhau *et al.,* 2020). According to the latest national report from Stats SA (2019) regarding food security in South Africa, the majority of households in Limpopo, Eastern Cape and KwaZulu-Natal rely on agricultural activities to supply their food so to boost household food security. This suggests that inland fisheries are a possible agricultural risk management strategy for rural households.

4.13.3. Multinomial logistic results for the VDM

The Multinomial logistic results for the VDM are presented in Table 4.28. The results show that out of eleven variables concerning mildly food security, only three were found to be significant, while two variables are significant with severe food insecurity. These variables are total household income (negatively significant at 5%) with severe food insecurity, marital

status (negatively significant at 10%) with mildly food insecurity. The variable distance to the market is negatively significant at 10% with mild food secure and positively significant at 5% with severe food insecure. The type of agricultural activity that households are involved in is negatively and statistically significant at 5% with mildly food insecurity.

Table 4.28: Multinomial logistic results for the VDM

Variables	dy/dx	Std. Error	Z	P>|z|
Mildly food insecure				
Age of household head	-.002	.002	-1.09	0.274
Gender of household head	.068	.051	1.33	0.184
Number of household members	.0004	.0089	0.04	0.967
Total household income	7.03e-07	4.51e-06	0.16	0.876
Marital status	-.028	.017	-1.72	0.086*
Level of education	.003	.019	0.15	0.883
Distance to market	-.006	.003	-1.86	0.063*
Reason for fishing	.015	.016	0.90	0.367
Type of agricultural activity	-.079	.029	-2.70	0.007***
Source of household head income	-.000	.006	-0.02	0.986
Distance to fishing area	.001	.001	1.45	0.147
Moderate food insecure				
Age of household head	.002	.002	0.91	0.361
Gender of household head	.069	.075	0.92	0.357
Number of household members	.017	.013	1.28	0.202
Total household income	-.000	7.89e-06	-1.32	0.188
Marital status	.000	.023	0.01	0.991
Level of education	-.014	.028	-0.49	0.625
Distance to market	.003	.005	0.63	0.527
Reason for fishing	.017	.025	0.71	0.479
Type of agricultural activity	.035	.045	0.78	0.434
Source of household head income	.011	.007	1.48	0.138
Distance to fishing area	.001	.001	0.94	0.348
Severe food insecure				
Age of household head	-.001	.002	-0.44	0.661
Gender of household head	-.015	.082	-0.19	0.852

Number of household members	-.021	.018	-1.14	0.253
Total household income	-.000	8.66e-06	-2.07	0.038**
Marital status	.022	.028	0.80	0.423
Level of education	-.026	.033	-0.77	0.444
Distance to market	.012	.006	1.94	0.053**
Reason for fishing	.011	.034	0.32	0.752
Type of agricultural activity	.0777	.051	1.53	0.126
Source of household head income	.005	.010	0.50	0.620
Distance to fishing area	-.002	.002	-1.08	0.280

Note: ***, ** and * indicate significance level at 1%; 5% and 10% respectively.

Source: Survey results (2021)

a) Marital status

The variable marital status resulted in a negative correlation with mildly food insecure suggesting that the household headed by a married person is likely to be food secure. The results further suggest that the food insecurity status might decrease from mildly food insecure to food secure by 0.028 units. Ndobo (2013); Akukwe (2020) however, revealed that households headed by unmarried people are likely to be food secure than households headed by married individuals. This might be because married household heads have higher responsibilities due to the increased household size as compared to an unmarried household head. However, this study argues that if the household head is married, both the husband and the wife can jointly work to make the household food secure. This can be done when both are employed or have an additional source of income such as inland fisheries.

b) Distance to the market

The variable distance to the market is negatively and statistically significant at 10% with mild food secure and positively significant at 5% with severe food insecurity. The marginal effects suggest that as the distance to the market decreases, households are likely to be food secure by 0.006%. However, the longer the distance to the market, the more the household might be severely food insecure. These results agree with the findings of Akukwe (2020) who found that long distance to the market increase the chance of the household being food insecure as compared to a shorter distance to the market.

c) Type of agricultural activity

Type of agricultural activity presented a negative correlation with mildly food insecure suggesting that if the household is involved in agricultural activities, that household is likely to be food secure by 0.79%. Agriculture plays an important role in reducing poverty and reducing food insecurity (United Nations report, 2015; Pawlak and Kołodziejczak, 2020). Moreover, a household involved in both agriculture and inland fisheries is likely to be food secure relative to the household not involved.

4.14. Summary of the contribution of inland fisheries to food security

The chapter discussed the results for the contribution of inland fisheries to household food security in Limpopo Province with the focus being SDM, MDM and VDM. Various analytical tools were used to analyse the data. For example, descriptive statistics in the form of percentages and Chi-square were used to describe the dietary diversity and food security differences between households involved in inland fisheries and those not involved. Therefore, these results show that the dietary diversity and food security status of these households are not significantly different.

In addition, descriptive statistics in the form of frequencies were used to elicit the types of fish consumed by households weekly. The results show that households in the three studied districts consume fish at least once a week. For instance, Tilapia, Catfish and Bass are the most preferred inland fish for households in SDM. On the other hand, some households buy tin/canned fish or Hake from stores. These fish are also consumed at least once a week. In like manner, households in MDM consume Tilapia, Bass, Carp and Catfish at least once a week. Tin/canned fish, Hake and other types of fish are also preferred by some households.

Regarding fish consumption patterns for households in VDM, the study found that the majority of the households preferred Catfish, Tilapia, Bass and Carp at least once a week. Moreover, tin/canned fish and Hake are also consumed at least once a week by some of the households. To this end, Tilapia, Catfish, Bass and Carp are the most consumed inland fish species by households in the three districts. Tilapia is the dominant fish species preferred for consumption by households in all the studied districts. However, tin/canned fish and Hake which are mostly bought at stores are also preferred by these households.

Another type of analytical tool that was employed in the study is the Binary Logistic Regression Model. This model was used to analyse the determinants of rural households' dietary diversity in the Limpopo Province. To achieve this, the study used step-wise

regression analysis. The Household Dietary Diversity was used as the dependent variable such that a Low Dietary Diversity was given the value of 1 while a high dietary diversity was given the value of 0. The results show that in SDM, access to credit, access to the market, number of years fishing, distance to the fishing area and the type of agricultural activity that the household is engaged in are the determinants of rural household dietary diversity. In MDM, level of education, distance to fishing area and source of income also determine the dietary diversity of households. Variables such as marital status, average quantity of fish caught, number of fishing labours and number of years fishing are the determinants of rural household dietary diversity in VDM.

The Multinomial Logistic Regression (MLR) was used to determine the effects of inland fisheries on household food security in the Limpopo Province. Firstly, Variance Inflation Factor (VIF) was used to test for the presence of multicollinearity. The results found that the variable used in the Multinomial Logistic Regression does not exhibit multicollinearity. Bearing that in mind, the MLR with four outcomes namely, food security, mildly food insecure, moderate food insecure and severe food insecure was used. However, food security as the first outcome was used as a reference category. The results show that in SDM several variables were found to be significant in different categories. For example, gender, household size, total household income, marital status and level of education are significant under mildly food insecure. Concurrently, household size, level of education and type of agricultural activity the household engages in are also significant under moderate food insecurity. Only marital status is significant under severe food insecurity in SDM.

Regarding significant variables in MDM, the study found that total household income, distance to the market and source of household income are significant under mild food insecurity. On the other hand, the type of agricultural activity and total household income are significant under moderate food insecurity. Total household income, distance to the market and type of agricultural activity are significant under severe food insecurity. Concerning variables that are significant in VDM, the study found marital status, distance travelled to the market and type of agricultural activity are significant under mildly food insecure. Additionally, total household income and distance travelled to the market are significant under the category of severe food insecurity in VDM.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATION

5.0. Introduction

This chapter summarises the empirical results of the study on the economic assessment of inland fisheries' contribution to income generation and food security in Limpopo Province, South Africa. The conclusions and policy recommendations in this chapter are drawn based on the results.

5.1. Research summary

This section presents the summary of the major findings from the results obtained in chapters 4 to make inferences of the hypotheses of the study. The study aimed to assess the contribution of inland fisheries to income generation and food security in the Limpopo Province. In pursuit of this aim, the study focused on three specific objectives. These objectives are to identify and describe socio-economic characteristics of households and the different roles and functions played along the inland fisheries value chain in the Limpopo Province, to determine the contribution of inland fisheries to household income and to determine the contribution of inland fisheries to household food security in the study area.

To achieve objective one, descriptive statistics, Pearson Chi-square and Pearson's Product Moment Correlation (*r*) were used. The descriptive statistics was employed to identify and describe the socio-economic characteristics of households and their functions along the inland fisheries value chain. The Pearson Chi-square and the Pearson's Product Moment Correlation (*r*) were used to check the relationship between socio-economic characteristics of the households (gender and age) and their function along the value chain.

The major findings drawn from these results are that majority of the participants in the study are male. For example, about 65% of the males in both SDM and MDM were interviewed. Moreover, 68% of the respondents in VDM are also males. Females account for 35% in both SDM and MDM while 32% are from VDM. Likewise, the study found the average age of respondents to be 48 years, 47 years, and 46 years in SDM, MDM and VDM, respectively (for the entire sample). However, the average age for fishing and non-fishing households is 47 years and 49 years in SDM. While the average age for fishing households in MDM and VDM is 47 years and 43 years, respectively. Similarly, the average age for non-fishing households in MDM and VDM is 47 and 49 years, respectively.

The average household size in the study was identified as 5 (in SDM) and 4 (in both MDM and VDM). On the other hand, fishing households have an average household size of 6 in SDM and 4 in both MDM and VDM. Fishers are likely to travel an average distance of 2.5km in SDM, 6.9km in MDM and 4.6km in VDM. Regarding average years that fishing households have been involved in inland fisheries, in SDM, 14 is the average years of fishing experience. In MDM and VDM, the average year of fishing experience is 21 and 8 years respectively. On average, fish is likely to be sold for R10.26c in SDM, R7.94c in MDM and R8.47c in VDM. These prices are measured in grams.

The study found that all the fishing households in the study area do not receive extension services. This is due to the lack of legislature to govern inland fisheries hence the sector is unrecognised and underappreciated. Furthermore, the study found that both males and females participate in inland fisheries. However, males dominate the sector. For example, about 26%, 80% and 70% of the males are small-scale fishers in SDM, MDM and VDM respectively. Contrarily, about 6% of females are small-scale fisherwomen in SDM while only 68% and 20% in MDM and VDM are small-scale fisherwomen.

Similarly, about 94%, 32% and 80% of the females' and, 74%. 20% and 23% of the male fishers in SDM, MDM and VDM are subsistence fishers. Only 7% of the interviewed recreational inland fishers are males from VDM. None of the females in the study reported being involved in recreational fisheries. Additionally, none of the males in SDM and MDM was reported being recreational fishers. Furthermore, all of the fishers reported having no fishing permits. To this end, most females participate in inland fisheries as subsistence fisherwomen.

Regarding the reasons for engaging in inland fisheries, about 57% (in SDM), 66% (in MDM) and 45% (in VDM) of the males' practice inland fisheries for consumption purposes compared to 77%, 55% and 62% of fisherwomen in SDM, MDM and VDM respectively. About 43%, 14% and 36% of males in SDM, MDM and VDM are involved in inland fisheries for business purposes respectively. About 23%, 25% and 38% of females in SDM, MDM and VDM respectively are involved in inland fisheries as a means of generating income. Moreover, about 20% of both males and females in MDM view inland fisheries as a hobby. Only 19% of the male fishers in VDM consider inland fisheries as a hobby. Remarkably, none of the fishers in SDM participated in land fisheries as a hobby. The major fish caught by fishers in SDM, MDM and VDM are Tilapia which is also preferred by most of the

households. The study concludes that fishers prefer fishing at state dams however, none have permits to practice fishing in these resources.

Concerning the value chain of inland fisheries results, the study identified input suppliers, fishers, processors, traders, and consumers as the major players of the inland fisheries value chain. Moreover, households engaged in inland fisheries participate in both pre- and post-harvesting activities. For example, from the identified role players, input supplying act as a pre-harvesting activity while, processing, trading, and consuming serve as post-harvesting activities.

To test the relationship between the socio-economic characteristics of role players and their function along the inland fisheries value chain, Pearson Chi-square and Pearson's Product Moment Correlation were employed. The Pearson Chi-square was employed to check the relationship between gender and function of role players while the Pearson correlation was used to check the relationship between age and function of role players. The results show that there is a relationship between gender and functions of a trader and consumer. Meanwhile, age of the household head has a positive relationship with the function of input supplier, processor and consumer. Furthermore, the study identified four marketing patterns of inland fisheries. These patterns incudes input suppliers who sell inputs to fishers (pattern 1), fishers sell raw fish to traders who sell to consumers (pattern 2), thirdly, fishers sell raw fish to processors who then sell to consumers (pattern 3) and, finally, fishers directly sell to consumers (pattern 4). These marketing patterns show marketing opportunities for participating in inland fisheries to generate income and sustain livelihoods.

The second objective was to determine the contribution of inland fisheries to household income. The fundamental hypothesis for this objective was that inland fisheries do not significantly contribute to household income. This objective only focused on households involved in inland fisheries. Therefore, different analytical techniques were used to address this objective. For instance, income share was used to calculate the share of income from fisheries to total household income. In this case, income from both fishing and non-fishing activities were considered.

The major findings drawn from the analytical results also show that both fishing and non-fishing activities contribute to the total household income. However, these contributions differ. For example, the major contributor of non-fishing activity to total household income in SDM and MDM is self-employment. Wage-earnings is the major contributor to VDM. In addition, the study found that income generated from inland fisheries is highly influenced by

various activities. For instance, selling of raw fish was identified as the high contributor to the total household income as a fishing activity. The second fishing activity that has a high proportion in the total household income is selling of processed fish. On average, households in SDM and VDM are likely to have medium diversity of income, while households in MDM have a low level of livelihood diversity. Therefore, these results show that inland fisheries contribute to the generation of household income.

Furthermore, the Multiple Linear Regression model was used to analyse the factors that influence the income of fishing households. Moreover, a multicollinearity test was carried out to check if the variables are highly correlated. The Multiple Linear Regression results show that distance to the market, average quantity of fish caught per kg/year access to credit, number of years fishing and type of inland fisheries positively influence the income of fishing households. On the other hand, reason for fishing negatively influence the income of fishing households. In addition, these results from the analysis confirm that these significant variables are the factors that contribute to the income of fishing households in the study area.

The study further determined the contribution of inland fisheries to household food security in the study area. The study hypothesised that inland fisheries does not significantly contribute to household food security. In pursuit of the objective, Household Dietary Diversity Scores (HDDS) and Household Food Insecurity Access Scales (HFIAS) were adopted as food security measures. The food security situation of household involved in inland fisheries and those not involved were determined. Descriptive statistics with Pearson Chi-square were used to check the differences between the food security situation of these households. Moreover, the study further determined the average HDDS and HFIAS in all the studies districts (that is; SDM, MDM and VDM).

The consumption pattern of households was also determined to find out how often do households consume inland fish. Moreover, a Binary Logistic Regression model was employed to investigate the determinants of rural households' dietary diversity in the Limpopo Province. The HDDS was divided into two groups. A Dietary Diversity of 0-5 shows LDD, where else a score of 6-12 indicates HDD. Therefore, LDD and HDD took the values of 0 and 1 respectively thus, Binary Logistic Regression was used.

In the interest of determining the effects of inland fisheries on household food security in the Limpopo Province, a Multinomial Logistic Regression model was used. Firstly, Variance Inflation Factor (VIF) was employed to test for the presence of multicollinearity. The

dependent variable (food security status) had four outcomes. The first outcome is food security, then mildly food insecure (second outcome). Outcome three and four is moderate food insecure and severe food insecure, respectively. Food security was then adopted as the base/reference outcome. Additionally, SPSS (for Binary Logistic) and STATA (for Multinomial Logistic) were used to run the analysis.

The study found that the food security situation of households involved in inland fisheries and those not involved is significantly different. In addition, the dietary diversity condition for these households in the three studied districts is normal. However, on average, the food security status of households in MDM is severe which agrees with prior studies. Concerning consumption pattern of fish by households, the study found that Tilapia, Carp, Bass, Catfish, canned/tin fish and Hake are the most preferred fish that households consume. Moreover, households are likely to consume fish from inland resources at least once a week.

The Binary Logistic results show that, access to credit, access to the market, number of years fishing, distance to the fishing area and the agricultural activity of the household are the determinants of rural households' dietary diversity. Similarly, level of education and source of income also determine the dietary diversity of households. Also, marital status, the average quantity of fish caught, and fishing labours are also the determinants of rural households' dietary diversity.

The results from Multinomial Logistic Regression also show that gender, household size, marital status and level of education are significant under mildly food insecure. On this account, having some form of educational background suggest that the households might learn how fish from inland waters have more nutrition as compared to farmed fish. Concurrently, household size, level of education and type of agricultural activity the household engages in are also significant under moderate food insecurity. Only marital status is significant under severe food insecurity in SDM.

On the other hand, total household income, distance to the market and source of household income are significant under mild food insecurity in MDM. The study concludes that having a short distance to the market suggests that households are likely to have access to the market where they not only purchase other food stuff but are likely to find a market where inland fish is sold. Type of agricultural activity and total household income is significant under moderate food insecurity in MDM. Total household income, distance to the market and type of agricultural activity are significant under severe food insecurity in multinomial results of MDM. Regarding multinomial variables that are significant in VDM, the study found marital

status, distance travelled to the market and type of agricultural activity as significant under mildly food insecure at VDM. Additionally, total household income and distance travelled to the market are significant under the category of severe food insecurity in VDM.

5.2. Conclusion

This section discusses the conclusion of the study based on the results obtained from SDM, MDM and VDM. The discussions are built on the objectives and the hypotheses of the study. Firstly, the study identified several role-players within the value chain of inland fisheries. The assumption was that households involved in inland fisheries only play the role of fishers and consumers. This hypothesis was therefore rejected because the study proved that households play multiple roles within the inland fisheries value chain. The study concludes that households play the role of input supplier, fishers, processor, trader, and consumer. In addition, these roles include several functions. For instance, the supplier oversees the provision of inputs such as bait, nets, and hooks. The primary function of the fishers is to catch fish. The study further infers that processors are responsible for adding value to the fish in the form of frying or drying. Similarly, the majority of the traders are price takers. However, these traders also play the role of processing the fish. Finally, both households involved in inland fisheries and those not involved consume fish from the inland waters. To this end, fishing households are involved in both pre-and post-harvesting activities within the value chain of inland fisheries.

The findings also confirm that inland fisheries in the studied districts contribute to household income. The fundamental hypothesis was that inland fisheries does not significantly contribute to household income in the study area. The study rejects this hypothesis and concludes that inland fisheries contribute to household income. The results from the income share show that fishing activities contribute to the total household income. For instance, selling raw fish contributes more to the total household income in SDM, MDM and VDM. Therefore, the income that is generated may assist households to purchase food and sustaining other livelihoods needs. Moreover, the study found that there are significant factors that influence the income of fishing households.

Thus far, the results also established that in SDM, MDM and VDM inland fisheries contributes to household food security. The central hypothesis was that inland fisheries does not significantly contribute to household food security in the study area. To test this hypothesis, several tools were used. These includes descriptive statistics, Binary Logistic Regression and Multinomial Logistic Regression. Although the dietary diversity and food

security status between fishing and none fishing households is significantly different, the study shows that households consume inland fish at least once a week. Likewise, the analysis of food security shows that there are variables that influence the dietary diversity and food security status of fishing and non-fishing households. Therefore, the study rejects the alternative hypothesis and concludes that inland fisheries does contribute to household food security in the selected districts.

5.3. Policy recommendations

The study's recommendations are based on the research findings. As a result of the study's findings and the literature reviewed, it is clear and widely accepted that inland fisheries play a significant role in improving household income and food security. This study, however, highlights the interrelationship between income generation, food security, and the value chain of inland fisheries, particularly in a rural context.

The majority of households in the study area currently benefit from inland fisheries in terms of income and food security. Furthermore, inland fisheries play an important role in the diversity of diets of rural households, and there are a variety of activities in which these households can participate in the value chain. Given this information, the study recommends the following:

1. The study's findings show that inland fisheries not only contribute to household food security, but also have the potential to improve dietary diversity of households. This necessitates the provision of awareness campaigns to households that are unaware of the benefits of venturing into inland fisheries, either directly or indirectly. Sustainable fishing practices, on the other hand, are recommended to protect and preserve the fish for long-term livelihood support. As a result, households will have a steady supply of fish. Relevant departments, such as the Department of Forestry, Fisheries, and the Environment, and the Department of Water and Sanitation, can help to ensure the sustainability of fish in waterbodies.
2. Similarly, the long distance travelled to the market limits fish accessibility and availability. As a result, policies that support local food markets should aim to develop rural marketplaces for inland fisheries. Inland fish, according to the literature, is by far healthier than farmed fish. As a result, low-income households and the unemployed should be encouraged to pursue inland fisheries as a source of food and income. Furthermore, the findings of the study show that households consume inland water

fish at least once a week. Thus, the government and other stakeholders should urgently raise awareness among households about how often fish from inland should be consumed. This is in light of the fact that studies have warned against consuming fish from metal-contaminated waters for an extended period of time. The Department of Health is one of the appropriate government departments to ensure this awareness.

3. The study discovered that majority of inland fisheries participants are men. Females participate in these activities at a lower rate. Various studies show that religion and traditions are some of the factors that prevent females from participating in fisheries; however, these females dominate post-harvesting activities. As a result, the findings of this study show that there is a link between gender and the function of a trader. Similarly, the formation of fish trading and processing associations will be the first step in encouraging female participation in inland fisheries. This type of association can then be led by the community with the assistance of the government to promote sector co-management. Thus, there is an opportunity for females in the inland fisheries value chain. This is consistent with South Africa's National Framework Policy for Women's Empowerment and Gender Equality, which aims to empower women to combat poverty and unemployment. As a result, there is a need to increase women's participation in inland fisheries and ensure that gender-sensitive programs are implemented to develop the sector and ensure women's representation.

4. The study discovered that most fishers are price takers, which impedes their efforts to generate more income and improve their livelihoods. As a result, these fishermen require both rural and urban communities to support access to different markets to better price their catch. The various markets will benefit not only the fishers, but also the communities through job creation. Although it is strongly advised that fishers obtain permits for these activities, the lack of inland fisheries governance places these fishers at a disadvantage along the inland fisheries value chain. The study recommends that the government expedite the implementation of the inland fisheries policy so that household activities are recognized as legitimate. In general, the inland fisheries policy opens the door for households to enter a profitable inland fishery.

5. Despite evidence of harvesting, processing, trading, and consumption of inland fisheries from the value chain, the study discovered that no government extension services are provided to these role players. This is due to the inland fisheries' lack of recognition and governance. The establishment of inland fisheries cooperatives and

extension services, on the other hand, will not only improve access to information but will also provide fishers with government and community support. Furthermore, Community Based Organizations (CBOs), which are non-profit organizations that work to improve the lives of their people, should be established to collaborate with the government in providing resources to fishing communities. These organisations can serve as information centres for fishing communities.

5.4. Future research

The thesis makes a significant contribution to inland fisheries in the Limpopo Province. Without a doubt, inland fisheries have the potential to contribute to rural households' income generation and food security. However, the study recommends more research on the scale of inland fisheries across the country to compare the societal, economic, and nutritional contributions of inland fisheries within each province. This will then provide a broader scale of information for the government to use to initiate and develop inland fisheries activities within each province.

When the inland fisheries is being developed, the research also provides timely information on its importance to rural livelihoods. Furthermore, the study could serve as a future reference for researchers interested in inland fisheries, particularly in South Africa, where it is undervalued. Given that inland water fishes are consumed by the majority of households, more scientific research on the nutritional and health benefits of each preferred fish species should be conducted. Similarly, studies on the value chain of these fish species should be conducted separately to determine their economic worth. Furthermore, additional research could be conducted to investigate the willingness-to-pay to access inland fisheries resources, the risks associated with inland fisheries and the necessary strategies to be implemented, the relationship between the contribution of an inland fisheries to food security and income diversity, and the factors that influence household participation in the inland fisheries.

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APPENDIX A: Consent form

SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Department: Agricultural Economics and Animal Production

CONSENT FORM

TITLE OF RESEARCH PROJECT: An economic assessment of inland fisheries' contribution to income generation and food security in Limpopo Province, South Africa

Dear Participant

This study aims to establish information related to inland fisheries for a better understanding of the nutrition and economic benefits to rural livelihoods.

Kindly be informed that your participation in the study is voluntary. You have the right to be a part of the study, choose not to participate or stop participating at any time without penalty. The answers given during this research will be treated as confidential information and the information obtained will be used only for this research.

There are no direct benefits from participation in the study, however, the study can only provide gathered information pertaining to the aim of the study given above.

For any enquiries concerning the study, you may contact the researcher via email at jenmkha@gmail.com or the supervisor at abenet.belete@ul.ac.za

CONSENT

I have read and understood the above information relating to the research and I am willing to participate in the study.

Signature of participant.....Date.....

WITNESS……..

APPENDIX B: Household and role players questionnaire

QUESTIONNAIRE

Jenny P. Mokhaukhau (Researcher) The University of Limpopo, Department of Agricultural Economics and Animal Production, School of Agriculture and Environmental Sciences, Faculty of Science and Agriculture, South Africa	Mobile: (+27) 72 950 1945 Email: jenmkha@gmail.com

Research topic: Economic assessment of inland fisheries' contribution to income generation and food security in Limpopo Province, South Africa

Aim of the study: The study aims to assess the contribution of inland fisheries to income generation and food security in Limpopo Province, South Africa.

Ethics: Participants will only be involved in the study out of their own will and their rights and privacy will be kept confidential and respected as required by the University of Limpopo Research Ethics Committee. Thus, the responses given during this research will be treated as confidential information and the information obtained will be used for purposes of research only.

Questionnaire number	
Name of enumerator	
Date of interview	
District Municipality	
Local municipality	
Name of Village	

SECTION 1: Demographic information (All respondents must complete this section)

For questions that need marking, please mark with an X or √

1. Age of household head ----------years
2. Gender

1. Male	2. Female

3. Number of household members----------
4. Total household income per month----------
5. Marital status of household head

1. Single	2. Married	3. Separated
4. Widow/er	5. Divorced	

6. Level of education of household head

1. Primary education	2. Tertiary education	6. Certificates
3. Secondary education	4. No education	

7. Do you have access to credit?

1. Yes	2. No

8. Do you have access to the market?

1. Yes	2. No

9. Distance to the nearest market……km

SECTION 2 A: Inland fisheries questions (All respondents must complete this section)

1. Which of the following inland fisheries are you involved in?*

1. Small-scale	2. Subsistence	3. Recreational	4. None

*Small-scale=mainly for selling the fish, with excess consumed; Subsistence=mainly for consuming the fish, with access sold; Aquaculture=fish farming

If None, answer ONLY a), b), c) and d) of SECTION 2A then move to SECTION 2B, SECTION 3B, SECTION 4 and SECTION 5

a) If None, where do you buy fish

1. Store	2. Hawkers	3. Fishers	4. Other: specify	5. None

b) Which type of fish do you buy and how much do you buy it for?

Type of fish	How much do you buy the fish?
Talapia	
Catfish	
Bass	
Troat	
Eel	
Tigerfish	
Hake	
Canned/Tin fish	
Other (Specify)	
None	

c) Do you buy processed fish or raw fish

1. Processed fish	2. Raw fish

d) Source of income of the household head

Source of income	Please mark with an X or √
Crop production	
Livestock	
Social grants	
Remittances	
Self-employment	
Wage-earnings	
Other (specify)	

2. Where do you normally fish?

1. State dams	2. River
4. Private dams	3. Other:

3. Do you have a license to access the fishing resources?

1. Yes	2. No	3. Rather not say

4. Number of years fishing/producing fish…….years

5. Distance to fishing area……..km

6. How often do you fish/produce fish?

1. Occasionally	2. Sometimes	3. Always

7. Which type of fish do you normally catch/produce?

1.Talapia	2.Catfish	3.Bass	4.Troat	5.Eel	6.Carp	7.Barbel
8.Tiger fish	9.Other (Specify)					

8. Type of fish sold per month

Type of fish	Price of each fish	Quantity/Number of fish per month
Talapia		
Catfish		
Bass		
Troat		
Eel		
Tigerfish		
Carp		
Barbel		
Other (Specify)		

9. Number of labourers employed by households for fishing activities

1. One labourer	2. Two labours	3. More than two labours	4. None

10. Reason for fishing

1. Consumption	2. Business	3. Recreational	4. Hobby	5. Other (Specify):

11. Do you receive extension services?

1. Yes	2. No

If yes, how often in a month?…….

13. Are you a member of any fishing co-operative?

1. Yes	2. No

If yes, how often do you meet per month……..

14. Type of transport used

1. Own transport	2. Hired transport	3. None

SECTION 2 B: AGRICULTURAL QUESTIONS

Which of the following agricultural productions is you involved in?

Agricultural activity	Name of production (e.g. vegetable, poultry)	Total income per annum
Crop production		
Livestock production		

SECTION 3: Share of inland fisheries to household income (All respondents must complete this section) * If NOT involved in inland fisheries ONLY answer A.

A. INCOME FROM NONE FISHING ACTIVITIES

Source of income	Contribution per month (in Rands)
Crop production	
Livestock production	
Social grants	
Remittances	
Self-employment	
Wage-earnings	
Other (specify)	

B. INCOME FROM FISHING ACTIVITIES

Source of income		Contribution per month (in Rands)
Loaning fish inputs	Gear	
	Rods	
	Hooks	
	Nets	
	Fridge	
	Boat	

	Other:	
Selling fish inputs	Gear	
	Rods	
	Hooks	
	Nets	
	Boat	
	Other:	
Repairing fish inputs	Gear	
	Rods	
	Hooks	
	Nets	
	Boat	
	Other:	
Packaging and transporting fish		
Fish marketing and distribution		
Selling processed fish		
Selling raw fish		
None		
Other (specify)		

SECTION 4: Food security (All respondents must complete ALL questions in this section)

1. For the following questions please mark with an X or √

HOUSEHOLD DIETARY DIVERSITY

In the past 7 days which of the following did, you consume?

Food group	Type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Cereals	Maize							
	Flour							
	Millet							
	Wheat							
	Bread							
	Barley							
	Sorghum							
	Rice							
Root tubers	Beetroots							
	Potatoes							
	Radish							
	Carrot							
	Sweet potatoes							
	Turnip greens							
Vegetables	Cabbage							
	Tomatoes							
	Beans							
	Lettuce							
	Spinach							
	Okra							
	Butternut							
Fruits	Apple							
	Orange							
	Banana							
	Strawberry							
	Lemon							
	Peach							
	Apricot							

	Plum							
Meat	Beef							
	Pork							
	Chicken							
	Mutton							
	Offal							
	Lamb							
Eggs	Duck egg							
	Chicken							
	Ostrich							
	Goose							
Fish and seafood	Mullet							
	Tuna							
	Red snapper							
	Catfish							
	Tilapia							
	Bass							
	Troat							
	Eel							
	Tigerfish							
	Carp							
	Barbel							
	Other….							
Pulse/legume /nuts	Cowpea							
	Chickpea							
	Peanut							
	Pigeon pea							
	Soybean							
	Common bean							
Milk and milk products	Milk							
	Yoghurt							
	Cheese							
	Milk-based desserts							

	Soymilk							
	Cream							
Oils/ fats	Almond Oil							
	Butter							
	Olive Oil							
	Sunflower Oil							
	Sesame Oil							
	Fish Oil							
Sugar/honey	Raw Honey							
	White sugar							
	Brown sugar							
	Sweetener							
	Filtered honey							
	Nectar							
Beverages	Tea							
	Coffee							
	Juice							
	Soft drinks							

2. HOUSEHOLD FOOD INSECURITY ACCESS SCALE GENERIC QUESTIONS

NOTE: All respondents must complete ALL questions in this section

For the following questions please mark with an X or √

Please answer whether this happened in the past 30 days. This question should be answered by household head or the person in charge of food preparation

NOTE: If the answer is YES, continue with the frequency of occurrence, if NO, go to next question.

Household Food Insecurity Access Scale	Yes	No	Frequency		
			Rarely	Sometimes	Often
1. Did you worry that your household would not have enough food?					
2. Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?					

3. Did you or any household member have to eat a limited variety of foods due to a lack of resources?					
4. Did you or any household member have to eat some foods that you did not want to eat because of a lack of resources to obtain other types of food?					
5. Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?					
6. Did you or any household member have to eat fewer meals in a day because there was not enough food?					
7. Was there ever no food to eat of any kind in your household because of a lack of resources to get food?					
8. Did you or any household member go to sleep at night hungry because there was not enough food?					
9. Did you or any household member go a whole day and night without eating anything because there was not enough food?					

NOTE THE FOLLOWING: Rarely (occurred once or twice), Sometimes (occurred 3 to 10 times) or Often (occurred more than 10 times) and Always (occurred every day)

SECTION 5: Role players in the inland fishery value chain (All respondents must complete this section)*

NOTE: Only households who are involved in inland fisheries and those who consume inland fish should fill this section

Please indicate the role you play in inland fisheries.

Role player	Function	Mark with X
Input suppliers	Provide inputs (bait, gear, rods, hooks, nets, fridge, boat, fuel, transport) to fishers	
	Provide guidelines on how to use the inputs	
	Deliver inputs to the fishers /households	
Household/ fishers	Catch fish (NPHAF)	
	Sell raw fish to traders/consumers	
	Process the fish for selling	
	Price maker	
	Price taker	
	Consume fish	
	Warehouse	
	Packaging and transportation	
	Marketing and distribution	
Hawkers	Purchase fish from household/ fishers	
	Sell fish to consumers	
	Process fish	
Processor	Gut the fish	
	Dry/fry fish	
	Sell fish to consumers	
	Gut the fish	
Consumers	Purchase fish from fishers	
	Purchase fish from traders	
	Price takers	

Note: NPHAF means not a post-harvesting activity but actual fishing

THANK YOU FOR YOUR PARTICIPATION

APPENDIX C: Ethical clearance certificate

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TURFLOOP RESEARCH ETHICS COMMITTEE

ETHICS CLEARANCE CERTIFICATE

MEETING: **05 March 2020**

PROJECT NUMBER: **TREC/38/2020: PG**

PROJECT:

Title:	An Economic Assessment of Inland Fisheries' Contribution to Income Generation and Food Security in Limpopo Province, South Africa
Researcher:	JP Mokhaukhau
Supervisor:	Prof A Belete
Co-Supervisor/s:	Dr JJ Hlongwane
School:	Agricultural and Environmental Sciences
Degree:	PhD in Agricultural Economics

PROF P MASOKO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **This Ethics Clearance Certificate will be valid for one (1) year, as from the abovementioned date. Application for annual renewal (or annual review) need to be received by TREC one month before lapse of this period.**

ii) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee, together with the Application for Amendment form.**

iii) **PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**

Finding solutions for Africa

APPENDIX D. Editor certificate

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13 October 2021

EDITORIAL CERTIFICATE

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DOCUMENT TITLE: **AN ECONOMIC ASSESSMENT OF INLAND FISHERIES' CONTRIBUTION TO INCOME GENERATION AND FOOD SECURITY IN LIMPOPO PROVINCE, SOUTH AFRICA**

This document certifies that the above Thesis was edited by Dr J R Rammala (PhD, Linguistics). The document was edited and proofread for proper English language, grammar, punctuation, spelling and overall style. The editor endeavoured to ensure that the author's intended meaning was not altered during the review. Track changes have been used in editing to allow the client to view the changes suggested.

Kind regards

Dr J R Rammala