ADDIS ABABA UNIVERSITY

AFRICA CENTER OF EXCELLENCE FOR WATER MANAGEMENT

Diversity, relative abundance and socio-economics of fish and fisheries in the western part of Lake Tana, Ethiopia

BY:

Sewunet Tegegne

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Addis Ababa, Ethiopia

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Diversity, relative abundance and socio-economics of fish and fisheries in the western part of Lake Tana, Ethiopia

MSc Thesis

BY

Sewunet Tegegne

A thesis presented in partial fulfillment of the requirements for the degree of Master of Science in Water Management Specialization in Aquatic Ecosystem Management

Advisors:

Prof. Abebe Getahun

November, 2020

Addis Ababa, Ethiopia

DECLARATION

I hereby declare that submission is my original thesis work with all sources of material used duly acknowledged and the work has not been presented for a degree in this or any other university.

Sewunet Tegegne Signature___________ Date ________

ADDIS ABABA UNIVERSITY AFRICA CENTER OF EXCELLENCE FOR WATER MANAGEMENT SCHOOL OF GRADUATE STUDIES

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The undersigned have examined the thesis entitled, **"Diversity, relative abundance and socio-economics of fish and fisheries in the western part of Lake Tana, Ethiopia"** by **Sewunet Tegegne**, a candidate for the degree of Master of Science in Water Management, specialization in Aquatic Ecosystem Management and here by certify that it is worthy of acceptance.

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ACRONYMS

ACSI	Amhara Credit and Saving Institution
AGP	Agricultural Growth Program
ANOVA	Analysis Of Variance
ANRS	Amhara National Regional State
ANRSLDPA	Amhara National Regional State Livestock Development and Promotion Agency
BDU	Bahir Dar University
Ca	Catch
CPUE	Catch per Unit Effort
ETB	Ethiopian Birr
FA	Fishermen Association
FAO	Food and Agricultural organization
FD	Fasting Day
FE	Fishermen Enterprise
FPME	Fish Production and Marketing Enterprise
GDP	Gross Domestic Product
IRI	Index of Relative Importance
MPS	Multi Probe System
MT	Metric Tone
NABU	National Biodiversity Conservation Organization
NFD	None Fasting Day
PAST	Paleontological Statistics Software Package

RDA	Redundancy Analysis
SPSS	Statistical Package for the Social Science

ABSTRACT

The fishery resource in Lake Tana has significant socio-economic contribution through generating income, employment and used as a cheap protein source for local people. However, diversity, relative abundance and socio economics of fisheries in the western part of Lake Tana were not well studied. So the aim of this study was to investigate diversity, relative abundance and socio economic value of fisheries in the western part of Lake Tana. The study was conducted from December 2019 to August 2020. Data were generated from field sampling, fishermen catch observations, key informant interviews, focus group discussions and through questionnaires. At the sampling sites, physico-chemical parameters were measured using MPS. Fish weights were measured from the fishermen catch at the landing sites. Data were analyzed by (PAST), SPSS software and by various descriptive statistics. A total of 6118 fish specimens were collected at all sampling sites. Thirteen fish species were identified with species diversity value 1.6. The evenness value in the western part of Lake Tana was J=0.62. All the fish species were present in all sampling sites, except that L. gorgorensis was absent at the sites of Kunzila and Delgi. O. niloticus (46.24%) was the most abundant species in number and C. gariepinus (28.39%) was the second and L. gorgorensis (0.6%) the least abundant species. From the value of (% IRI), Oreochromis *niloticus was the most important species during the dry season with value of 22.48 % and C. gariepinus was the most important species with the IRI value of 32.67% during the wet season. L. crassibarbis was the least important species with the IRI value of 0.23% during the dry season and L. gorgorensis was the least important species in the wet season with the IRI value of 0.31%. 18.16 % of variance was positively correlated with environmental variance with C. gariepinus, L. nedgia, L. truttiformis, L. tsanensis and O. niloticus. The total fish catch composition in the study area were O. niloticus (54.3%), C. gariepinus (23.4%) and Labeobarbus spp. (22.3%). The fishing activities in the study area were 87.8% fishing alone and 12.2% fishing in groups. The majority of fishermen were used monofilament gillnets (64%) and only 36% used multifilament gillnets. The fishermen who fished alone and those in groups had an average income of 1907.75 and 3210.42 ETB, respectively (P< 0.05). The average income who had owned modern and traditional boats were 3300.00 and 1907.75 ETB, respectively: (P<0.05). The current fishing trends in the study area and the fishery conditions were threatened. Therefore,* *appropriate management action should be taken especially to control monofilament fishing gears in order to sustain the fishery resources in Lake Tana.*

Key words: *Diversity, fish, fisheries, Lake Tana, relative abundance, socio-economics*.

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Ethiopia is the water-tower of Eastern Africa and has a number of inland water bodies. The total area and length of these water bodies are estimated to be about 13,637 km^2 and 8065 km, respectively (Gashaw Tesfaye and Wolff, 2014) and a mean annual flow of these water bodies is estimated to be about 122 billion m^3 (Seleshi Bekele *et al*., 2007). These freshwater bodies are enclosed into 6-12 drainage basins and are home to a high diversity of fishes (Golubtsov and Darkov, 2008; Redeat Habteselassie, 2012; Abebe Getahun, 2017; Alamrew Eyayu, 2019).

Ethiopia has a rich diversity of Ichthyofauna in its lakes, rivers and reservoirs (Abebe Getahun and Stiassny, 1998 and Tesfaye Melak and Abebe Getahun 2012). As of now, more than 200 fish species have been recorded from the country of which 191 are native species included in 11 orders and 29 families (Abebe Getahun, 2017). There are also about 18 undescribed species and 9 exotic fish species introduced from abroad into Ethiopian freshwaters (Abebe Getahun, 2017 and Yibeletal Aynalem *et al*., 2018). The number of endemic fish species of the country is estimated to be 53 (Abebe Getahun, 2017 and Alamrew Eyayu, 2019).

The highest species diversity in Ethiopia has been recorded from Baro-Akobo Basin, followed by Omo-Turkana, Abay and Wabi-shebelle Basins (Alamrew Eyayu, 2019) (Table 1). The highest fish diversity might be attributed due to the presence of diverse and rich habitat in terms of food availability, connection with other ecosystems and a relatively higher degree of exploration done on these water bodies (Felegush Erarto *et al*., 2020). In Ethiopia, fish species diversity increases with decreasing altitude. This is because of the steep altitude gradients and occurrence of rich lowland fauna in most basins (Golubtsov and Mina, 2003 and Alamrew Eyayu, 2019). The endemicity seems to be highest in Abay and Awash basins (Tesfaye Melak and Abebe Getahun, 2012). The highest endemicity in the Abay basin is due to the endemic species flock of Lake Tana and the presence of some endemic fishes adapted to localized habitats in small streams in the highland of northern and central part of Ethiopia

(Tesfaye Melak and Abebe Getahun, 2012 and Abebe Getahun, 2017). This is attributed, in the former case, by the endemic species flock of *Labeobarbus* in Lake Tana, because it involves an intact species flock; the *Labeobarbus* that evolved in a genetically and geographically isolated system. Lake Tana is separated from the lower Blue Nile basin by 40 m high Tisisat Falls.

Lake Tana emerged as one of the global top 250 lake regions most important for biological diversity (Barker, 2004). Lake Tana is found in the north-western part of Ethiopia with high production potential and diversity of fish fauna, having a diversified species in the inland water bodies (Shibru Tedla, 1973; Abebe Getahun, 2002 and Gizachew Teshome *et al*., 2015). There are 28 species of fish in Lake Tana out of which 21 are endemic to the country. The most significant genus is *Labeobarbus* consisting of 18 species including *Labeobarbus ossensis, Labeobarbus degeni* (Abebe Getahun and Eshete Dejen, 2012) and *Labeobarbus beso* (Abebe Getahun, 2017; Shewit Gebremedhin *et al.*, 2018) forming a species flock, the only remaining cyprinid species flock in the world after the ones in Lake Lanao, Philippines, have decimated (Abebe Getahun, 2009, and Tesfaye Melak and Abebe Getahun, 2012).

Ethiopia has high production potential and diversity of fish fauna. The territory of Ethiopia seems to be among the regions of African continent which are least explored for their ichthyofauna (Golubtsov *et al*., 1995). The current total fish production potential is estimated at about 94,500 tonnes per year, out of these only 20 % is currently utilized in Ethiopia (Gashaw Tesfaye and Wolff, 2014). This is due to the wholesale of the commercial catch comes from very few species, and decreased productivities of these fish may easily lead to a subsequent decline in the overall catch and natural variability of stock sizes.

Fisheries are one of livelihood strategies that have contributed much to people in developing countries. It is one of the vital strategies for the poor to achieve food, income and other social benefits. Fish has historically played an important role in food security in many countries and continues to do so globally, providing 15-20 percent of animal protein intake (FAO, 2003; Sugunan *et al*., 2007). The fishery sector can be considered a marginal sector in terms of the aggregated economic output in Ethiopia. It is estimated that the sector accounts for about 0.1% of the national GDP whose contribution to budget revenue is negligible.

According to Kidanie Misganaw and Addis Getu (2016) stated Lake Tana fishery is open access in practice and there is no well-developed fish market system in the study area. Besides, illegal trading, absence of clear market policies, fishing during peak spawning and breeding time, lack of standard and grades of fish and poor supply of export market are common problems in the region (Kidanie Misganaw and Addis Getu, 2016). The Lake Tana fisheries are clearly very important to the local population, employing more than 6,000 people in fishing, marketing, and processing (Aytegeb Anteneh, 2013; Yeshizerf Shumye, 2016). According to Sewmehon Demssie (2003) the fishery resource has significant socio-economic contribution through generating income, employment and used as a cheap protein source for local people in developing countries including Ethiopia. Therefore, the overall objective of the study was to determine the diversity, relative abundance and socio-economics of fishes and fisheries during the dry and wet seasons in the western part of Lake Tana. The results of this study are useful for appropriate management and sustainable utilization of fishery resources in Lake Tana.

1.2. Statement of the problem

In Lake Tana fisheries, there are ten districts that have a potential for fishing and more than 6000 fishers have been engaged in fishing in a seasonal and full time basis at this time (Erkie Asmare, 2018). Due to the expansion of water hyacinth invasive weed in Lake Tana, especially on the eastern and north eastern parts; especially around the shore area, fishing is too much difficult. This results in blockage of fish landing sites and destruction of fishing gear and fishermen change their landing sites to the neighboring districts. On the other hand, an area of sparsely infested water hyacinth obstructs the speed of fishing boat by raveling the propeller. This reduces the energy of the motorized boat without reducing the amount of fuel consumed (Erkihun Asmare, 2018). According to Dagninet Amare *et al*. (2018) the annual fish production potential of Lake Tana is 18688.27 tonnes out of which 10570.99 tonnes (56.56%) of fish production is from the western part of Lake Tana indicating that there is more production of fish than predicted by others (de-Graff *et al*., 2006). During breeding season, *Clarias gariepinus*, *Oreochromis niloticus* and *Labeobarbus* species were highly overfished, especially in the shore area at the river mouth. Currently, the fishing activity in Lake Tana appears to have shifted and there is increased pressure of motorized commercial gillnet fisheries in the western part of Lake Tana. Therefore, this study assessed the diversity, relative abundance and socio-economics of the fishes and fisheries in the western part of Lake Tana for appropriate management and sustainable utilization of the resources.

1.3. Research questions

1. What are the physico-chemical features of the water in the sampling sites?
2. What is the species diversity and relative abundance of the fishes in the study area?
3. What are the fishing categories, fishing boats and marketing system of the fisheries in the western part of Lake Tana?
4. How are the fishing activities related to the income and the livelihood of the fishermen?

1.4. Objectives

1.4.1. General objective

The general objective of this study is to generate base line scientific information/data about fish diversity, relative abundance and socio- economic value of fishes and fisheries for appropriate management and sustainable utilization of the fish resources in the western part of Lake Tana.

1.4.2. Specific objectives

The specific objectives of the study are to:

- Measure physico-chemical parameters at the different sampling sites.
- Determine the fish species diversity in the western part of Lake Tana.
- Evaluate the relative abundance of fish species in the western part of Lake Tana.
- Examine the fishing activity at the fishing and landing sites.
- Assess the socio- economic value and marketing of fish in three woredas (North Achefer, Alefa and Takusa) in the western part of Lake Tana.

1.5. Significance of the study

This study will provide relevant information mainly on diversity, relative abundance and socioeconomic value of fish in the western part of Lake Tana. Such information also serves as basic inputs for fishery managers, FAO, Ministry of Livestock and Fisheries and research and academic institutions.

1.6. Arrangement of the thesis

The thesis is organized into five chapters. The first chapter deals with the introduction, statement of the problem, significance of the study and objectives of the study. Chapter two deals with literature review. The third chapter describes the materials and methods. The fourth chapter presents the results and discussions and the fifth chapter describes conclusions and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Physico-chemical parameters

Aquatic organisms are highly dependent upon the characteristics of the aquatic habitat, which supports all their biological functions (reproduction, growth, feeding and sexual maturation). Thus, abiotic factors are the controlling factors for the aquatic life, since they shape most of the biological functions of aquatic life (Murdoch and Martha, 1999). Dissolved oxygen is required for respiration by most aquatic animals. Each species of fish has a preferred or optimum temperature range where it grows best. At temperatures above or below optimum, fish growth is affected. Mortalities may occur at extreme temperatures (Piper *et al*., 1982). The high salinity and TDS in the aquatic ecosystem result in physiologically stressful conditions for some species of aquatic organisms due to alterations in osmotic conditions (Assefa Wosnie and Ayalew Wondie, 2014). Turbidity determines light penetration in water. This in turn will have an effect on the temperature of the water and the amount of vegetation and algae that will grow in the water, thus affecting the rate of photosynthesis and primary productivity (USDA, 1996). Physical and chemical parameters of Lake Tana such as temperature, total dissolved solids, pH and conductivity have previously been recorded (Eshete Dejen *et al*., 2004).

2.2. Flora and fauna

The littoral region of Lake Tana is dominated by emergent macrophytes such as papyrus reed (*Cyprus papyrus*), common cattail (*Typha latifolia*) and a common reed (*Phragmites karka*), *Echinochloa pyramidalis*, *Echinochloa stagnina*, *Polygonum barbatum* whereas *Persicaria senegalensis*, hippo grass (*Vossia* spp.), bullrush (*Scirpus* spp.) and floating leaved species *Nymphae lotus*, *Nymphaea caerulea* and *Pistia stratiotes* are common (Hughes and Hughes, 1992). The most dominant submerged macrophytes in Lake Tana are *Ceratophyllum demersum* and *Vallisneria spiralis* (Hughes and Hughes, 1992). There are 44 zooplankton species in Lake Tana of which sixteen species of rotifers, sixteen cladocerans and twelve copepod species were recorded (Ayalew Wondie, 2006). *Bosmina longirostris*, *Daphnia hyalina*, *Daphnia lumholtzi* and *Diaphanosoma sarsi* were the most abundant cladoceran species in Lake Tana (Eshete Dejen *et al.,* 2004).

The most common vertebrates in Lake Tana are bird species such as great white pelican (*Pelecanus onocrotalus*), African fish eagle (*Haliacetus vocifer*), Egyptian goose (*Alopochen aegytiaca*), King fisher and common crane (Felegush Erarto *et al*., 2020) and the common mammal found in Lake Tana is Hippopotamus (*Hippopotamus amphibious*) (Wassie Anteneh, 2013).

2.3. Diversity and relative abundance of fishes

Relative abundance is the number of organisms of a particular kind as a percentage of the total number of organisms of a given area or community (Shewit Gebremedhin, 2011). Lake Tana contains four families of fish: *Balitoridae*, *Cichlidae*, *Clariidae* and *Cyprinidae* (Vijverberg *et al.*, 2009). *Balitoridae*, *Cichlidae* and *Clariidae* are represented by single species each*: Afronemacheilus abyssinicus Oreochromis niloticus* and *Clarias gariepinus*, respectively (Abebe Getahun *et al*., 2008). The family *Cyprinidae* is the largest family of freshwater fishes (Nelson *et al*., 2016). *Cyprinida*e is represented by four genera: *Barbus*: represented by three species: *B. humilis, B. pleurograma* and *B. tanapelagius* (Eshete Dejen *et al*., 2003); *Garra*: represented by four species: *G. dembecha, G. dembeensis, G. regressus* and *G. tana* (Abebe Getahun, 2000; Stiassny and Abebe Getahun, 2007; Akewake Geremew, 2007; Vijverberg *et al.*, 2009 and Gizachew Teshome *et al*., 2015).

Labeobarbus is the most abundant genus of the family and consists of 18 species forming a unique species flock in Lake Tana (Nagelkerke and Sibbing, 2000; Abebe Getahun and Eshete Dejen, 2012, Gizachew Teshome *et al*., 2015 and Shewit Gebremedhin *et al.*, 2018). The *Labeobarbus* spp. of Lake Tana had been previously classified under the genus Barbus (Abebe Getahun *et al*., 2008). However, large, diverse, hexaploid African Barbus are renamed as *Labeobarbus* by adding the prefix 'large' (Berrebi and Tsigenopoulos, 2003; Snoeks, 2004 and Abebe Getahun *et al*., 2008). The larger species of the genus *Barbus* of Lake Tana include several distinct morphological varieties. Based on morphological appearance of the fish, local names such as 'gobit', 'afe-dist', 'afe-muti', 'lonte' which means respectively 'big hunch', 'big-mouth', 'pointed mouth', 'big lip', are used to identify the different types (de Graaf *et al*., 2004). *Labeobarbus* spp. are hexaploid and well diversified in their distribution and feeding ecology (Nagelkerke *et al*., 1994; Nagelkerke, 1997; Sibbing and Nagelkerke, 2001; de Graaf, 2003 and Shewit Gebrmedhin, 2011). They are distinguished into five trophic groups based on gut content analysis and morphological prediction: zooplanktivore-insectivore (*L. brevicephalus*); molluscivore (*L. gorgorensis*); macrophytivore (*L. surkis*); four species that feed on benthic invertebrates (mainly insect larvae) (*L. crassibarbis*, *L. intermedius, L. nedgia*, and *L. tsanensis*) and eight piscivores (*L. acutirostris, L. dainellii, L. gorguari, L. longissimus, L. macrophthalmus, L. megastoma, L. platydorsus, L. truttiformis*).

Cyprinids are riverine in their origin and they are adapted to live in lakes or lacustrine environments. However, most of these species still migrate upstream to spawn in tributary rivers (Tomasson *et al*., 1984; Skelton *et al*., 1991) which indicates that they are not still fully adapted to the lake environment. Different studies conducted in some tributary rivers of Lake Tana such as Gelgel Abay, Gelda and Gumara (Nagelkerke and Sibbing, 1996; Palstra *et al*., 2004; de Graaf *et al*., 2005), Ribb, Dirma and Megech Rivers (Wassie Anteneh, 2005; Abebe Getahun *et al*., 2008) and Arno-Garno River (Shewit Gebremedhin, 2011) showed the upstream spawning migration of some lacustrine *Labeobarbus* spp.

Eight (*Labeobarbus acutirostris, Labeobarbus brevicephalus, Labeobarbus intermedius, Labeobarbus macrophtalmus, Labeobarbus megastoma, Labeobarbus platydorsus, Labeobarbus truttiformis* and *Labeobarbus tsanensis*) are reported as riverine spawuners (Abebe Getahun *et al*., 2008). But, the remaining seven 'missing' *Labeobarbus* spp. (*Labeobarbus crassibarbis, Labeobarbus dainellii, Labeobarbus gorgorensis, Labeobarbus gorguari, Labeobarbus longissimus, Labeobarbus nedgia* and *Labeobarbus surkis*) have been assumed either migrating or spawning in Arno-Garno River (Abebe Getahun *et al*., 2008). These species might be lacustrine spawners (Nagelkerke and Sibbing, 1996; Palstra *et al*., 2004; de Graaf *et al*., 2005; Abebe Getahun *et al*., 2008; Shewit Gebremedhin, 2011 and Yibeletal Aynalem *et al*., 2018).

Apart from *Labeobarbus* species, *Clarias gariepinus* and *Oreochromis niloticus* contribute to the majority of the catches (de Graaf *et al*., 2004). *Oreochromis niloticus* is most abundant in the shallow littoral zone, while *C. gariepinus* and the piscivorous *Labeobarbus* species are found mainly in the deeper open water areas of the lake (de Graaf *et al*., 2004). According to Dagninet Amare *et al.* (2018) the Lake Tana fishermen ranked Nile tilapia (75%) and *Labeobarbus* spp. (25%) during autumn season, *Clarias gariepinus* (54.84%), *Labeobarbus* spp. (38.71%), and Nile tilapia (6.45%) during summer and Clarias *gariepinus* (44%), *Labeobarbus spp*. (40%) and Nile tilapia (16%) during winter. This indicated that fish abundance is dependent on spatial and partly temporal variation.

Seasonally, fish abundance ranges from highest to lowest in autumn, summer, spring and winter.

2.4. The fishing activities in Lake Tana

Fishing in Lake Tana started by the Negedie Woyto ethnic group, which did not have their own farm land. The Negedie Woyto ethnic group has exploited Lake Tana fisheries since the 18th century. Until the mid-1980s, fishing activity was almost completely limited to subsistence (Tesfaye Wudneh, 1998). During this period, the fishing activity was restricted to shore areas and only simple single person papyrus reed boats were used. Subsequently, poor members of the farming communities gradually adapted to fish consumption and subsistence fishery (Aytegeb Anteneh, 2013). The fishing gears were locally made traps, hooks and lines, and small gill nets. In 1986, two Dutch Non-Governmental Organizations together with Ethiopian Ministry of Agriculture and Orthodox Church initiated the modernization of the lake fisheries (Shewit Gebremedhin *et a*l., 2018).

Currently, there are both reed boat and motorized gillnet fishery in Lake Tana. About 80% of the fishers use reed boats and the remaining 20% have motorized boats for fishing (Shewit Gebremedhin *et al*., 2013). The number of motorized boats engaged in Lake Tana increased from 5 in 2000 to 80 in 2010 (de Graaf *et al*., 2004) and the number of reed boats from 400 in 2000 to 1500 in 2010 (de Graaf *et al*., 2004; Berhan Mohammed *et al*., 2013 and Esthete Dejen *et al*., 2017). According to Dereje Tewabe (2015) almost all fishers using both reed boat and motorized boat fishing mainly concentrate on breeding season and spawning grounds of the species.

Oreochromis niloticus fishing is carried out at littoral regions, while *C. gariepinus* is caught at flooded areas, littoral and river mouths. *Labeobarbus* is mostly targeted at river mouths and a little distance towards upstream (Felegush Erarto *et al*., 2020). The social and economic importance of fish production in the region can be explained by the different types of producers engaged in fishing. Based on their fishing methods and their purpose of fishing, fish producers around Lake Tana can be categorized into two major groups. These are indigenous people who catch fish using traditional fishing gears that are used primarily for household consumptions and, individual fishermen and co-operatives who catch fish using relatively modern methods and equipment and supply their products to the nearby markets (Yeshizerf Shumye, 2016).

The commercial gillnet fishery of Lake Tana is known to have developed rapidly, total catches increasing from 39 MT in 1987 to 360 MT in 1997 (Tesfaye Wudneh, 1998). The total number of gillnets also increased steeply; in 2011 20 times more gillnets were set than in 2001 (Berhan Mohammed *et al*., 2013; Shewit Gebremedhin *et al*., 2013).

The majority (58.5%) of the fishers undertake fishing as a full time activity while few (14.6%) were involved in fishing as a part-time activity. There are also other groups of fishers (26.8%) that are involved in fishing seasonally (Dagninet Amare *et al*., 2018).

2.5. Marketing and distribution of fishes

The fishermen present the fishes in the western of Lake Tana to the market in different forms depending on the demand of customers and the type of fish species and the size of fish captured by fishermen. According to Brook Lemma (2012) export of fish products from Ethiopia to the international market of Europe and other Asian countries were difficult since 2005 because none of Ethiopian fish processors and exporters could meet the international fish trade requirement. But without any stringent and quality control Ethiopia export dried fish from Lake Tana fishery to Sudan incredibly.

The Ethiopian fish market has been growing increasingly, and the volume of catch was largely handled by FPME (Lemma Abera, 2016). FPME is the main supplier of fish from Lake Tana to Addis Ababa (Abebe Getahun *et al.,* 2008). An estimated 40% of the fish handled by FPME nationally is sourced from Lake Tana (Abebe Getahun *et al.,* 2008). The main source of FPME supplier is Tana Haik number one fishing cooperative (Abebe Getahun *et al.,* 2008). It has been estimated that 45% of cooperatives' catch is sold at local markets (Aytegeb Anteneh, 2013; Yeshizerf Shumye, 2016). Local trader organization named “Saint George”, with a collector boat, has been known to sell an estimated 40% of the catch principally to local restaurants and hotels including those in the small towns north of Bahir Dar and Gondar (Aytegeb Anteneh, 2013).

The urban fish market is highly grown and has recently seen the opening of new retail outlets. 63.89% of the fishers sell fish at landing sites while 36.11% sell at nearby markets. Lake Tana has more than eight fish landing sites, all of them are not officially recognized and hence illegal fishing takes place at these sites (Aytegeb Anteneh, 2013). The major fish marketing places for fishers are nearby markets which covered 41.38% while; Bahir Dar number one fishers' cooperatives covered 27.59% and the landing sites take 3.45% (Dagninet Amare *et al.*, 2018). The price of fish varies by fish species, type of product and place of market (Sewmehon Demissie, 2003; Yeshizerf Shumye, 2016). The fishers like to sell their catch in numbers as selling on weight has low income. The species sold on weight basis are mostly *C. gariepinus* and *Oreochromis niloticus*.

2.6. Contribution of fisheries to livelihood

The fishery resource has significant socio-economic contribution through generating income, employment and used as a cheap protein source for local people in developing countries including Ethiopia (Sewmehon Demissie, 2003). Livelihood is an aggregate measure of how people or a given population (as small as a household of a single person) makes their living within the limit imposed by the environmental, social, economic and political conditions of the society within which they live (Ajala, 2008). Fisheries are one of livelihood strategies that have contributed much to people in developing countries. It is one of the vital strategies for the poor to achieve food, income and other social benefits. For instance, it serves as an important source of food for over one billion people (Manasi *et al*., 2009; Shewit Gebremedhin *et al.*, 2013) and provides employment for about 38 million people around the world (FAO, 2003). The fishery sector in Ethiopia plays an appreciated role in terms of providing employment with estimated number of 45 000 fishers involved (14000 being fulltime fishers and 26700 part-time fishers). Women are mainly involved in processing, net making and retail trading (FAO, 2014).

The Lake Tana fisheries and adjacent wetlands provide directly and indirectly a livelihood for more than 500,000 people (Dumont, 2009). Private fishers (82.9%) dominate in Lake Tana fishing activity while 17% are members of different fishing cooperatives (Dagninet Amare *et al*., 2018).

The major livelihood for 19.5% of the fishers depends on agriculture while 46.3% of the fishers depend entirely on fishing as the major livelihood source. Almost 34% of the fishers support their livelihoods both on fishing and partly on agriculture and the fishers secure an average annual income of ETB 15076.73 by providing whole, gutted and filleted fishes to different consumers and customers (Dagninet Amare *et al*., 2018). At the moment, the Lake Tana fisheries contribute annually 65 million ETB to the economy of the Amhara region (ANRSLDPA, 2011). Approximately 20% of the catch (14 million ETB) is exported to Sudan (Shewit Gebremedhin *et al.*, 2013). According to FAO (2014) the annual fish catch in Ethiopia constitutes 80% from lakes, 7% from rivers and 13% from dams and small water bodies **(**Table 1). Thus, the lakes' contribution was great in comparison with other water bodies.

Table 1. The fish production potential in different water bodies in Ethiopia (Gashaw Tesfaye & Wolff, 2014)

Water bodies	**Area (km^2)**	**Length (km)**	**Fish production potential (tons/year)**
Major lakes	7740	-	39, 262
Major reservoirs	1447	-	7879
Small water bodies	4450	-	25, 996
Rivers	-	8065	21, 405
Total	**13, 637**	**8065**	**94, 541**

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Amhara Regional State located in north western part of Ethiopia. It was conducted in the western part of Lake Tana, in North Achefer, Alefa and Takusa Woredas bordering the lake. The study area is 610 km far from Addis Ababa and 105 km from Bahir Dar, the capital city of Amhara Regional State (Fig.1).

Lake Tana, the largest lake (area 3156 km^2) in Ethiopia is the source of the Blue Nile and is located between latitude 10°58'–12°47'N and longitude 36°45'–38°14'E. Lake Tana is shallow lake with an average depth of 8 m and a maximum of 14 m depth. It has a maximum length of 78 km, width of 67 km, and a shoreline of 385 km (Tadese Fetahi *et al*., 2018). The lake comprises 50% of the total lake resources of the country. Seven large, permanent rivers and more than 60 small seasonal rivers feed Lake Tana (Wassie Anteneh *et al*., 2012). It is characterized by low nutrient concentrations, relatively high silt concentrations with a loading rate of 8.96-14.84 million tons of soil per year (Birru Yitaferu, 2007) and the trophic status is an oligo-mesotrophic (Nagelkerke, 1997; Tesfaye Wudneh, 1998; Berhanu Teshale *et al.*, 2002; Ayalew Wondie *et al.*, 2007, Goraw Goshu *et al*., 2010). The North Achefer woreda is found in west Gojjam zone, the capital town is Liben. Alefa and Takusa woredas are found in central Gondar zone whose capital towns are Shahura and Delgi, respectively.

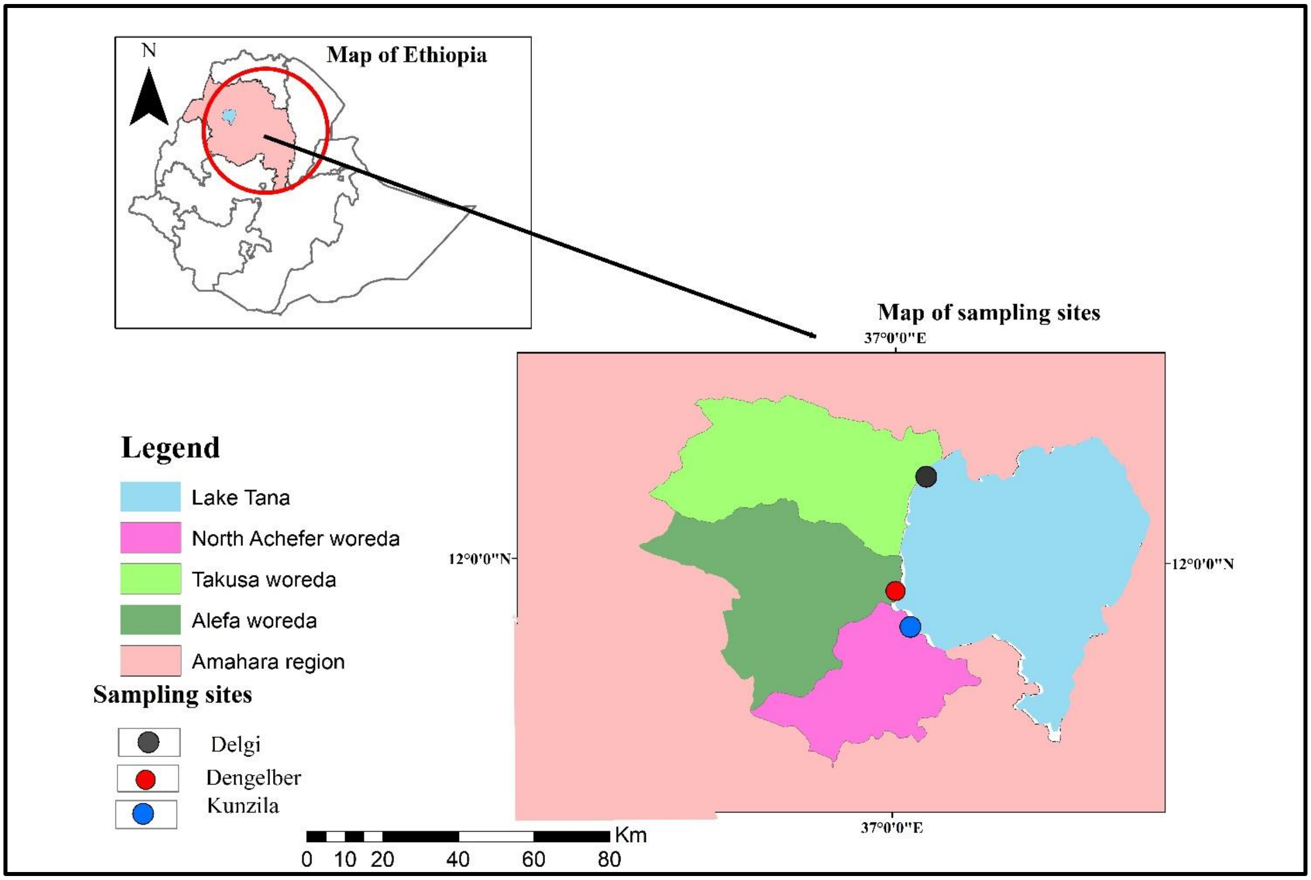

Figure 1. Map of the study area

3.2. Site selection

The sampling sites were selected after a reconnaissance survey was conducted at the North Achefer, Alefa and Takusa Woredas. Hence, three sampling sites were selected based on accessibility of fishing landing sites (road), the number of fishers and fishing activities. Geographical Positioning System (GPS) was used to determine the locations of the sampling sites (Table 2). Fish sampling and physico-chemical parameters were collected at the three sampling sites monthly from December 2019 to July 2020.

Table 2. GPS coordinates of sampling sites of the study area

District	Sampling sites	Cod	Distance from Kunzila (Km)	Coordinates
North Achefer	Kunzila	K01	___________	11°52'33''N 037° 02'10 ''E
Alefa	Dengelber	Dbr02	10	11°57'08''N 037°01'11'' E
Takusa	Delgi	D03	65	12° 11'27 ''N 037°03'20'' E

3.3. Field sampling

3.3.1. Physico-chemical parameters

Physico-chemical parameters of water in the western part of Lake Tana that include÷ Toc, DO, conductivity, TDS, salinity and pH were measured from three sampling sites using in-situ MPS 556. Physico-chemical parameters were measured monthly from each site (December 2019 to July 2020) for six months from the same direction of the fishers set fishing gears. The physico- chemical parameters were measured on open water at all sampling sites. The Secchi depth was measured with 20 cm diameter.

3.3.2. Fish sampling methods and fish identification

Fishes were sampled parallel to the physico-chemical sampling, every month the fishes were collected at all sites using variety of fishing gears, which included gill nets of various mesh sizes from

December 2019 to July 2020 excluding March and April. The fishes were collected by gill nets of various mesh sizes (6 cm to 12 cm stretched mesh size), monofilament nets with (5 mm to 55 mm stretched mesh size) and multiple long-lines with hooks of different sizes (9, 10, 11 and 12). The gears were set at the mid-day at all sampling sites and the fish collected at the morning for six months. The total number of individual species (N) and total weight (W) were measured at all sampling sites. The fishes were identified to species level in the western part of Lake Tana using keys developed by Nagelkerke and Sibbing (2000) and Abebe Getahun (2017) and with an experienced technical assistant from the laboratory of Bahir Dar Fisheries and Other Aquatic Life Research Center.

3. 3.3. Fish diversity and species evenness

The diversity of fishes in the western part of Lake Tana was identified by counting the number of fish species at the three landing sites. Shannon's diversity index ("H") was used to indicate diversity at different sampling sites (Næsje *et al*., 2004).

"H" was calculated as-:

$$H' = - \sum_{i-1}^{s} \frac{ni}{N} ln \frac{ni}{N}$$

Where, "H"= the Shannon- Weiner Diversity Index

Σ=Sum from species 1 to species S

ni= Number of individual of species"i"

N= Total number of individual of all fish species

S=Total number of fish species

Species evenness is the measurement of the relative abundance of different species, in a way to show the richness of the area (Felegush Erarto *et al*., 2020). According to Shannon (1949) stated that the index value above 3 indicates that the structure of the habitat is stable and balanced; values below 1 indicate that there are pollution and degradation of habitat structure. According to Odum (1971) states the diversity index value, H' ≤ 1 = Low diversity, 1 < H'≤ 3 = Moderate diversity and H '≥ 3 = high diversity.

Species evenness was calculated as:

Species evenness = i / Ln ((s-1) / Ln (n))

Where,

s = Number of species recorded

n = Total number of individuals in the sample

i = Shannon's Diversity Index

3.3.4. Relative abundance

An ‘’Index of Relative Importance” IRI (Pinkas *et al.*, 1971; Caddy and Sharp, 1986; Kolding, 1989, 1999) will be used to find the most important species in terms of number, weight and frequency of occurrence in catches from the different sampling sites. IRI gives a better representation of the ecological importance of species rather than the weight, number or frequency of occurrence alone (Sanyanga, 1996 and Gizachew Teshome *et al*,. 2015).

An Index of relative importance (% IRI) was calculated as:

$$\%IRI = \frac{(\%Wi + \%Ni) * \%Fi}{\sum_{j-1}^{s} (\%Wj + \%Nj) * \%Fj} * 100$$

Where *j* =1-S, Wi % and %Ni is percentage of weight and number respectively, of each species (i) in the total catch; % percentage of frequency of occurrence of each species in the total number of settings, and S is total number of species .

3.4. Socio economic data collection

The socio-economic data were collected in Kunzila, Dengelber and Delgi through group discussion, key informant interview, direct observation and structured questionnaire at all sampling sites (Table 2).

3.4.1. Sample size determination

There are about 741 fishermen engaged in fishing activities in the three districts, 13 Kebeles at Lake Tana and 3 Kebeles at little Abay River in the western part of Lake Tana (Table 3).

Table 3. The number of fishermen engaged for fishing activities in western part of Lake Tana (Source: North Achefer, Alefa and Takusa woredas livestock and fishery development office)

District	Kebele	Number of fishermen			Remark
		Male	**Female**	**Total**	
North Achefer	Wenberia	8	-	8	
	Kunzila	75	8	83	
	Estumit	145	20	145	
	Chimba River	35	-	35	Little Abay
	Shobila River	28	-	28	Little Abay
	Gug River	26	-	26	Little Abay
	Sub-total	**317**	**28**	**345**	
Alefa	Esey debir	67	-	67	
	Dengelber	61	8	69	
	Beles-Zirge	19	-	19	
	Achamangure	7	-	7	
	Sub-total	**154**	**8**	**162**	

Takusa	Delgi	86	-	86	
	Chechihuna	24	4	28	
	Chenkie	33	-	33	
	Achera	27	-	27	
	Mekonta	56	-	56	
	Ayimba	4	-	4	
	Sub-total	**230**	**4**	**234**	
Grand Total		**701**	**40**	**741**	

The Kebeles were selected purposely to determine sample size based on the accessibility of landing sites. The sample size for the study were taken based on Arsham (2005) a ±5 percent degree of precision level and 95 percent confidence interval.

Hence:

$$n = \frac{N}{1 + N(e)^2}$$

Where n=The required sample size. N= The number of total fishermen

e= The desired level of precision. Using this formula, the sample size of the study is determined to be 197 fishermen (Table 4). The simple random sampling technique was used to select the 197 fishermen out of the total fishermen.

Table 4. The numbers of fishermen were selected for structured questionnaires

Districts	**Kebeles**	**Number of fishermen (N)**	**Sample size (n)**
North Achefer	Kunzila	83	69
Alefa	Dengelber	69	57
Takusa	Delgi	86	71

Grand Total	197

3.4.2. Questionnaire survey

The socio-economic data were collected in the study areas from December 2019 to February 2020 through semi -structured questionnaires (Appendix 10). Before launching the questionnaires the purpose of the survey was made clear to the subjects and the survey was conducted in Amharic. The questionnaire was pre-tested through three respondents randomly selected from each study area.

The content of the questionnaire includes general questions related to experts and respective local government bodies, individual fishermen and fishermen association and it was about demographic structure, livelihood contribution of fisheries, utilization patterns of fish products, distribution and the marketing system, challenges of the fishery and management approach of fishery in the study area.

3.4.3 Group discussions and Key informant interviews

Focus group discussions were held in each study area after filling out the questionnaires by way of interviewing. Members of the focus group discussion were selected purposefully and include a total of eight members from each district. The members include local elders, individual fishermen and farmers and local administrative office.

The key informant interview was conducted with fishery experts and Kebele livestock and fishery development agents of each woreda. The focus group discussion and key informant interview were held mainly on the challenges, the trend and management system of the fisheries in the western part of Lake Tana.

3.4.4. Secondary data

The secondary data were collected from published and unpublished sources from livestock and fishery development offices of North Achefer, Alefa and Takusa woredas as well as Bahirdar fishery and other aquatic life research center. Moreover, documented information related to the study, such as books, brochures and research reports were reviewed.

3.5. Data analysis

The data were analyzed using Microsoft office, excel and word 2013. SPSS 20 version software was used to compute correlation analyses and some other descriptive statistics. PAST (Paleontological Statistics software package) version 4.03 was used to determine the Shannon diversity index and evenness value of fish. One-way ANOVA was used to analyze the income difference between fishers who owned modern and traditional boats, as well as those that carried out fishing activities alone and in-groups. Abiotic parameters were analyzed by descriptive statistics.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Physico-chemical parameters of the study sites

Physical and chemical parameters such as temperature, dissolved oxygen (DO), pH, total dissolved solids (TDS), specific electrical conductivity, salinity and water transparency (Secchi depth) from all sampling sites were analyzed using descriptive statistics and there was significant difference ($P<0.05$), except salinity at all sampling sites (Table 5& Appendix 1).

Table 5. The physico-chemical data obtained from different sampling sites in the western part of Lake Tana

Parameters	**Kunzila**	**Dengelber**	**Delgi**	
	Mean ± SE	Mean ± SE	Mean ± SE	**Average**
Toc (°c)	22.5 ±0. 3	22.05±0.27	22. 5 ±0. 47	**22.36±0.2**
DO (mgl^{-1})	6.79±0.1	6.91±0. 017	6.91±0. 017	**6.89±0.06**
pH	6. 95±0. 06	7.08±0.07	7. 09±0. 14	**7.04±0.09**
Conductivity (µs/cm^{-1})	138. 83±5	134.75±2. 3	130. 97±2.	**134.85±3.4**
TDS (ppt)	112. 67±6	106. 33±8.13	100.50±3.6	**106.28±5.9**
Salinity (ppt)	0.07±0.0	0.07±0.0	0.07±0.0	**0.07±0.0**
Secchi depth (cm)	52.17±21. 5	57.67±9.7	61.50±10.06	**57.1± 13**

Like other land organisms, aquatic populations are also highly dependent upon the characteristics of the aquatic habitat, which supports all their biological functions (reproduction, growth, feeding and sexual maturation). Thus, abiotic factors are the controlling factors for the aquatic life, since they shape most of the biological functions of aquatic life (Murdoch and Martha, 1999). Fish naturally have a tendency to select the habitat that is most suitable for their physiological requirements. Particularly, physico-chemical properties of the water can affect the distribution of fish species in aquatic environments (Reash and Pigg, 1990). There are considerable variations between fish species in its tolerance range of variations of water parameters.

The mean values of temperature measured in the study sites ranged from 22.10 ±0.2°C to 22.5 ±0.5°C. The minimum temperature was recorded at Dengelber in December 21.00°C and maximum was measured at Delgi 24.5°C in May. This might be due to the fact that the vegetation coverage at the site of Dengelber is better compared to the others along the shore of the lake. The variation in water temperature causes, change in the metabolic activities of fish, which results in the variation of body condition, species abundance species distribution in the lake (Adane Fenta and Almaz Kidanemariam, 2016).

Adequate concentration of dissolved oxygen (DO) is a critical factor for the survival of fish species. DO below 3 mg/ L is stressful to most aquatic organisms and DO content 5 to 6 mg/ L is usually required to perform the normal biological functions (Campbell and Wildberger, 1992). The average concentration of DO in the western part of Lake Tana varied between 6.79±0.1 and 6.98±.07mg/ L. The highest DO value was recorded at the study area and this might be due to high vegetation coverage and low water temperature in the study area (Felegush Erarto *et al*, 2020). The high water temperature might have caused the less DO contents in the water. This is because the solubility of oxygen decreases with the increase in water temperature, salinity and water depth (Ali *et al*., 2013; Wetzel, 2001). The average DO value in the western part of Lake Tana is 6.89±0.06 mg/ L. These is greater than 6 mg/ L which is required for fish to perform their biological functions (Felegush Erarto *et al*, 2020). The mean DO value of our study is similar to the value reported in Lake Tana sub-basin (6.7 to 7.8 mg/ L) (Shewit Gebremedhin *et al*., 2014) and greater than the finding of Mathewos Temesgen (2017) from Lake Langeno (5.2 mg/ L) and from Lake Zeway (3.5 to 6.0 mg/ L) (Lemma Abera, 2016). However, it was less than that of Lake Hawassa (11.2-20.6 mg/ L) (Admasu Woldesenbet, 2015) and Lake Chamo (10.3-17.4 mg/ L) (Adane Fenta and Almaz Kidanemariam, 2016). The variation in DO may also depend on phytoplankton composition, seaweed and other aquatic plants in the water, which produces DO as a waste product of photosynthesis (Jaeger *et al*., 2017).

In the present study, the results obtained for pH as the mean ± SE values ranged from 6.95±0.06 to 7.09±0.14 (Table 5). The average pH value is similar to Lake Tana (6.8-8.3) (Eshete Dejen *et al*., 2004) and Lake Tana sub-basin (6.69-7.48) (Shewit Gebremedhin *et al*., 2014). The pH value of water at the western part of Lake Tana was almost neutral at all sampling sites. However, it was less than that of Lake Langeno (9.45) (Mathewos Temesgen, 2017), Lake Zeway (8.84-8.66) (Girma Tilahun and Ahlgren, 2010), Lake Hawassa (6.98-7.59) (Begashaw Abate *et al.*, 2015), Lake Abaya (7.85-9.0) (Zinabu Gebremariam *et al*., 2002) and Lake Chamo (8.45-9.02) (Adane Fenta and Almaz Kidanemariam, 2016). The significant difference in pH among the sampling sites is attributable to the presence of phytoplankton coverage along the shore of the lake and the amount of allochthonous materials that enter into the lake.

The average specific conductivity in the study area was 134.85±3.4 (µs/cm) which was higher than the conductivity value of Lake Tana (132.8 µs /cm) reported by Eshete Dejen (2004) and Felegush Erarto *et al*. (2020). However, it was less than that of Lake Tana sub-basin 185.24±2.09 (µs/cm) (Felegush Erarto *et al*, 2020), Lake Zeway (361.5±9.7 to 484.5±15.3 µs/cm) (Lemma Abera, 2016), Lake Langeno (1782.1 µs/cm) (Mathewos Temesgen, 2017). The lowest value of specific conductivity was recorded 130.97±2.8 (µs/cm) at Delgi and the maximum was recorded 138.83±5 (µs/cm) at Kunzila. This might be due to differences in human activities, vegetation cover, geological factors in the catchment and other environmental difference in the lake and its tributary rivers (Felegush Erarto *et al*, 2020). The variation in electrical conductivity of inland waters depends on concentration, charge and mobility of ions in the water, which is directly affected by water temperature, TDS and salinity (Miller *et al*., 1988).

The mean value of TDS in our study is 106.28±5.9 ppm (Table 5). The minimum TDS was recorded at Delgi (100.50±3.6 ppm) and the highest TDS was recorded at Kunzila (112.67±6 ppm). The variation of TDS in the study area might be due to the higher vulnerability of runoff in the catchment area. The TDS value in the present study is less compared to Lake Tana sub-basin (122.22±2.58 mg/ L) (Felegush Erarto *et al*, 2020), (163.6 mg/ L) (Eshete Dejen *et al.*, 2004), Lake Zeway (270.0 mg/ L) Berhanu Rabo (2008), Lake Hawassa (455.6 mg/ L) Admasu Woldesenbet (2015), Lake Chamo (656.0 mg/L) Adane Fenta and Almaz Kidanemariam (2016) and Lake Langeno (1512.9 mg/ L) (Mathewos Temesgen, 2017). According to Weber-Scannell and Duffy (2007) the difference in concentration of TDS in natural waters is determined by the geology of the drainage basin, atmospheric precipitation, anthropogenic activities and the water balance.

The mean salinity value, in the present study is 0.07 ppt. During the present study, the salinity value of water at the western part of Lake Tana was the same at all sampling sites.

On the other hand, the mean Secchi depth in our study is 57.1±13.8 cm. The lowest Secchi depth (52.17±21.5 cm) was recorded at Kunzila and highest (61.50±10 cm) was recorded at Delgi. However, the minimum Secchi depth (22 cm) was recorded at Kunzila in July and the maximum (86 cm) was at Delgi in February. The lowest Secchi depth was recorded at the study sites, which was strongly associated with the rainy season of the study area. This might be due to high sedimentation load, as a result of the contribution of the Little Abay River and run-off drain to the lake in the catchment area. The Secchi depth in the study area was highest comparable with Lake Langeno (15.7±0.2 cm) (Mathewos Temesgen, 2016), Lake Ziway (17.85 to 22.12 cm) (Lemma Abera, 2016) and part of Lake Turkan (19.88±1.38 cm) (Mulugeta Wakjira, 2016). The increment in turbidity was reflected by the low Secchi depth measured during the study period (Lemma Abera, 2016). SD seems more reasonable to compare since it will denote turbidity and sedimentation.

4.2. Fish species composition in the western part of Lake Tana

During the present study, a total of 6118 fish specimens belonging to 13 species categorized under three families were collected from the study area from December 2019 to July 2020, excluding March and April (Table 6 &Appendix 2). Cyprinidae was the most dominant family in terms of the number of fish species. Out of the total catch, 11 species were from family Cyprinidae and under the genus *Labeobarbus* which contributed about 25.35 % of the total catch. Family Cichilidae, which is composed of one species (46.24%) is dominating followed by family

Clariidae (28.39%) in the catch (Table 6). *Oreochromus niloticus* (46.24%) was the most abundant species in number followed by *C. gariepinus* (28.39%) in the catch. This is similar to the report of Demeke Admassu *et al*.(2015a) and Lemma Abera (2016) who stated that *O. niloticus* was the most abundant fishes in lake Ziway and widely distributed in different water bodies. This might be due to its high tolerance to a wide range of environmental conditions. *Labeobarbus intermedius* is the most abundant species within the genus *Labeobarbus* contributing 8.3% of the catch. *Labeobarbus gorgorensis* (0.6%) was the least abundant species in the catch. Even though there are 28 fish species found in Lake Tana only 13 fish species were sampled during the present study. This might be due to differences in the sampling efficiency, habitats and seasonal variations.

Table 6. The total species composition collected in the western part of Lake Tana.

Species	**Number**	**Percentage**	**Family**
Clarias gariepinus	1737	28.39	Clariidae
Labeobarbus brevicephalus	81	1.32	Cyprinidae
Labeobarbus crassibarbis	79	1.29	
Labeobarbus gorgorensis	37	0.6	
Labeobarbus intermedius	508	8.3	
Labeobarbus longissimus	129	2.11	
Labeobarbus macrophatalmus	58	0.95	
Labeobarbus megastoma	111	1.81	
Labeobarbus nedgia	108	1.77	
Labeobarbus platydorsus	234	3.82	
Labeobarbus truttiforms	126	2.06	
Labeobarbus tsanensis	81	1.32	
Oreochromis niloticus	2829	46.24	Cichilidae
Total	**6118**	**100**	

4.3. Fish species distribution in the study sites

A total of 13 species of fishes in the families of Cyprinidae, Clariidae and Cichilidae were identified from three different sites in the western part of Lake Tana (Table 7). In the present study, *L. gorgorensis* was only collected at Delgi site in both dry and wet seasons. However, *L. macrophtalmus* and *L. crassibarbis* were not collected at this site during the dry season. *Oreochromus niloticus* and *C. gariepinus* were commonly distributed at all sampling sites in the study area. This is similar to the result of Mathewos Temesgen (2017) in Lake Langeno, in which *Oreochromis niloticus* was the most abundant fish species throughout the lake. Biotic and abiotic factors, and seasonal changing of habitat may cause the seasonal variations in ichthyofaunal distribution. On the other hand, *Oreochromus niloticus* was the most abundant fish species in Gubi Reservoir, Nigeria (Maigari, 2018). *Oreochromis niloticus* was also the dominant species especially in Lake Kenya boli Lake Victoria baisin.

Table 7. Fish species identified from the western part of Lake Tana during dry and wet seasons (present (+) and absent (-))

Family	Fish species	Sampling sites					
		Kunzila		Dengelber		Delgi	
		Dry	Wet	Dry	Wet	Dry	Wet
Clariidae	*Clarias gariepinus*	+	+	+	+	+	+
Cyprinidae	*Labeobarbus brevicephalus*	+	+	-	+	+	+
	Labeobarbus crassibarbis	+	+	+	+	-	+
	Labeobarbus gorgorensis	-	-	-	-	+	+
	Labeobarbus intermedius	+	+	+	+	+	+
	Labeobarbus longissimus	+	+	+	+	+	+
	Labeobarbus	+	+	+	+	-	+
	macrophatalmus	+	+	+	+	+	+
	Labeobarbus megastoma	+	+	+	+	+	+
	Labeobarbus nedgia	+	+	+	+	+	+
	Labeobarbus platydorsus	+	+	+	+	+	+
	Labeobarbus truttiforms	+	+	+	+	+	-
	Labeobarbus tsanensis						

Cichilidae	*Oreochromis niloticus*	+	+	+	+	+	+

4.4. Relative abundance of fishes

4.4.1. Numerical abundance of fishes

The catch proportion as well as numerical abundance of the three families that exist in the western part of Lake Tana were *O. niloticus* (42.59%), *C. gariepinus* (29.83%) and *L. intermedius* (9.58%) and these fishes were caught in both wet and dry seasons (Table 8).

Of the total specimens that were collected, 3362 (55%) were caught during the wet season (May to July) and the remaining 2756 (45%) specimens were caught during the dry season (December to March). In the wet season, a total of 1432 specimens of *O. niloticus* were collected from all the study sites. *Oreochromis* was the most dominant species in terms of the number from all the sampling sites.

This is in agreement with Njiru *et al*. (2008) that stated the dominance of *O. niloticus* over other species in Lake Victoria, which may be attributed to adaptation to the habitat, flexible feeding habit and fast growth rate. *Clarias gariepinus* was the second most dominant species next to *O. niloticus* in the catch. The total number of specimens of *O. niloticus* and *C. gariepinus* were 2829 and 1737, respectively. Even though the abundance of *L. gorgorensis* was small in number, the catch was relatively high in wet season (Table 8). Seasonally, the catch of the commercially important fishes (*O. niloticus*, *C. gariepinus* and *L. intermedius*) were more dominant in the wet season. The highest number of fish was caught during the wet season in the study area and this may be due to the fact that the fishes were in the breeding time and had high chance to be captured with fishing gears (Lemma Abera, 2016).

In the dry season, the total number of O. niloticus and C. gariepinus from all the sites were 1397 (50.69 %) and 734 (26.63%), respectively. The remaining commercially important fish species were different species of the genus *Labeoburbus* such as *L. brevicephalus*, *L. crassibarbis, L. gorgorensis*, *L. intermedius*, *L. longissimus*, *L. macrophthaus*, *L. megastoma*, *L. nedgia*, *L. platydorsus*, *L. truttiformis*, and *L. tsanensis* that contributed 625 (22.7%) during the dry season (Table 8).

Table 8. The contribution by number of each fish species in the total catch during dry and wet seasons in the study area (December 2019-July 2020), excluding March and April.

Fish species	Seasons											
	Dry					Wet					Overall	
	Kun	Dng	Dlg	Total	%	Kun	Dng	Dlg	Total	%	Total	%
Clarias gariepinus	216	209	309	734	26.	221	401	381	1003	29.83	1737	28.
Labeobarbus brevicephalus	14	0	14	28	1.0	12	22	19	53	1.58	81	1.3
Labeobarbus crassibarbis	3	12	0	15	0.5	25	16	23	64	1.90	79	1.3
Labeobarbus gorgorensis	0	0	12	12	0.4	0	0	25	25	0.74	37	0.6
Labeobarbus intermedius	58	30	98	186	6.7	121	113	88	322	9.58	508	8.3
Labeobarbus longissimus	16	35	19	70	2.5	25	16	18	59	1.75	129	2.1
Labeobarbus macrophtalmus	5	6	0	11	0.4	12	19	16	47	1.40	58	0.9
Labeobarbus megastoma	14	9	7	30	1.1	29	20	32	81	2.41	111	1.8
Labeobarbus nedgia	20	22	29	71	2.6	13	13	11	37	1.10	108	1.8
Labeobarbus platydorsus	24	46	36	106	3.9	43	47	38	128	3.81	234	3.8
Labeobarbus truttiformis	7	20	21	48	1.7	31	26	21	78	2.32	126	2.0
Labeobarbus tsanensis	17	11	20	48	1.7	8	25	0	33	0.98	81	1.3
Oreochromis niloticus	289	626	482	1397	50	322	504	606	1432	42.59	2829	46.

Total	**683**	**1026**	**1047**	**2756**	**100**	**862**	**1222**	**1278**	**3362**	**100**	**6118**	**100**

4.4.2. Abundance of fish species in relation to seasonal variations

All of the fish species were collected in all of the sampling periods. The highest number of catch, which is dominated by *O. niloticus* was collected in months of January and May. Similarly, highest number of *C. gariepinus* was collected in May and June. This is perhaps because the period is the time of spawning. The result is similar with the report by Dereje Tewabe (2010) in which it was mentioned that the catch of *C. gariepinus* was recorded in Lake Tana in June and July, which is the spawning season. Relatively, high number of *L. intermedius* was collected in May and June. Generally, high number of fish specimens were collected in May and June, whereas, it was very small in December and July (Fig. 2).

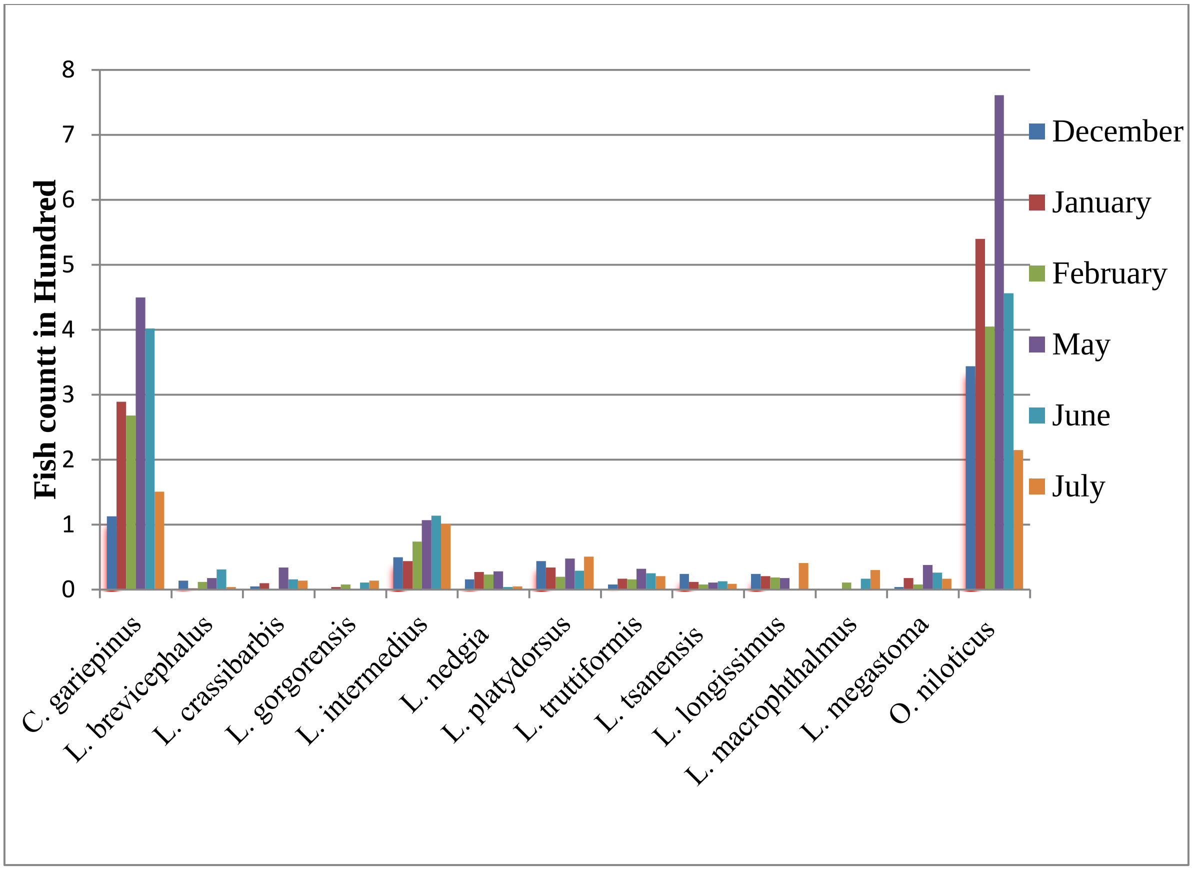

Figure 2. Abundance of fish species in relation to seasonal variations in the western part of Lake Tana

4.4.3. Relative abundance of fishes during wet and dry seasons

A total number of 6118 fishes with a total weight of 2455 kg were caught from the western part of Lake Tana during the study period (Table 9). The species compositions in all the sampling sites were ranked based on the Index of Relative Importance (IRI). The highest number of individual fishes were caught at Delgi (2325) (Appendix 3). This might be due to the fact that the majority of the fishermen were using monofilament gears at this site, and this may have contributed to the highest number fishes compared to the other sites. The second highest number of fish individuals were caught at Dengelber (2248) (Appendix 4) and the least number of fishes were recorded at Kunzila (1545k) (Appendix 5). On the other hand, the highest weight of fish was caught at Dengelber (999kg) and the least weight was caught at Delgi (631kg). In the present study, *O. niloticus* was the most important species during dry season with IRI value of 22.48 %. However, *C. gariepinus* was the most important species during wet season with the IRI value of 32.67%. *Clarias gariepinus* was the most important species at Kunzila and Delgi with IRI value of 37.1% and 34.6%, respectively (Appendix 5 & 3). But, *O. niloticus* was the most important species at Dengelber with IRI value of 38.1% (Appendix 4). This might be due to the level and status of vegetation cover at Dengelber that was better than the other sites. The absence of vegetation cover and high depth of the lake could be the responsible factors for the scarcity of the fish species in the lake (Mathewos Temesgen, 2017). The IRI value of *O. niloticus* at Kunzila and Delgi was 27.5% and 26.2%, respectively. *Labeobarbus crassibarbis* was the least important species with the IRI value of 0.23% during dry season and *L. gorgorensis* was the least important species in wet season with the IRI value of 0.31%. *L. intermedius* was the highest important species from family Cyprinidae during dry and wet season with the IRI value of 14.9 % and 15.66 %, respectively.

Fish species	**Dry season (December, January and February)**							
	N	**%N**	**W**	**%W**	**F**	**%F**	**IRI**	**%IRI**

Clarias gariepinus	734	26.63	455.5	33.2	9	33.33	1133.19	22.27
Labeobarbus brevicephalus	28	1.02	17.5	1.3	3	33.33	44.35	0.87
Labeobarbus crassibarbis	15	0.54	7.5	0.5	3	22.22	11.65	0.23
LLabeobarbus gorgorensis	12	0.44	8	0.6	2	100	60.44	1.19
Labeobarbus intermedius	186	6.75	109	7.9	9	100	796.75	15.66
Labeobarbus longissimus	70	2.54	52	3.8	9	100	382.54	7.52
Labeobarbus macrophtalmus	11	0.40	5.5	0.4	9	55.56	22.62	0.44
Labeobarbus megastoma	30	1.09	22	1.6	5	100	161.09	3.17
Labeobarbus nedgia	71	2.58	66.5	4.8	9	66.67	322.60	6.34
Labeobarbus platydorsus	106	3.85	91	6.6	6	66.67	443.87	8.72
Labeobarbus truttiformis	48	1.74	48	3.5	6	77.78	273.97	5.38
Labeobarbus tsanensis	48	1.74	40.5	2.9	7	100	291.74	5.73
Oreochromis niloticus	1397	50.69	450.5	32.8	9	33.33	1143.91	22.48
Total	**2756**	**100.00**	**1373.5**	**100.0**			**5088.72**	
Wet season (May, June and July)								
Clarias gariepinus	1003	29.83	330.5	30.56	9	100	3085.8	32.67
Labeobarbus brevicephalus	53	1.58	20.5	1.90	5	55.56	107.1	1.13
L. Labeobarbus crassibarbis	64	1.90	38.5	3.56	8	88.89	318.3	3.37
L. Labeobarbus gorgorensis	25	0.74	14	1.29	2	22.22	29.4	0.31
Labeobarbus intermedius	322	9.58	144	13.31	9	100	1340.6	14.19
Labeobarbus longissimus	59	1.75	32.5	3.01	5	55.56	169.0	1.79
Labeobarbus macrophtalmus	47	1.40	25.5	2.36	6	66.67	158.7	1.68
Labeobarbus megastoma	81	2.41	49	4.53	9	100	455.4	4.82
Labeobarbus nedgia	37	1.10	19.5	1.80	5	55.56	101.1	1.07
Labeobarbus platydorsus	128	3.81	72	6.66	9	100	669.8	7.09
Labeobarbus truttiformis	78	2.32	53	4.90	8	88.89	437.9	4.64
Labeobarbus tsanesis	33	0.98	16	1.48	4	44.44	66.8	0.71
Oreochromis niloticus	1432	42.59	266.5	24.64	9	100	2506.6	26.53
Total	**3362**	**100.00**	**1081.5**				**9446.6**	

Table 9. Percentage of IRI of the collected species in the study area in both wet (May, June and July) and dry seasons (December, January and February)

4.4.4. Abundance of fish species in relation to environmental variables

The first axes of Redundancy analysis (RDA) showed 9.9% of the species-environment variance (Table 10). The RDA ordination of the species-environmental association indicated that TOc, DO, Conductivity and TDS were the most determinant factors that affect the abundance of different fish species because such variables had a long arrow length (Felegush Erarto *et al*, 2020). The RDA ordination of the species-environment association indicated that pH, Secchi depth and salinity were positively correlated with *L. brevicephalus*, *L. crassibarbis*, *L. gorgorensis*, *L. intermedius* and *L. macrophthalmus* in the first axis. Secchi depth and TDS were positively correlated with *L. brevicephalus*, *C. gariepinus* and *L. macrophthalmus* in the first axis. The vector length for different environmental variables is also referred as the relative importance of that variable for predicting the fish assemblage and their abundance (Felegush Erarto *et al*, 2020).

Table 10. Redundancy Analysis (RDA) of biplot the relationship between environmental variables and fish abundance using the first two Axes.

Parameters	**Axis 1**	**Axis 2**
Eigenvalues	1.684	1.403
Cumulative percentage variance of species with environment relation	9.9	18.16
Temperature	-0.130876	-0.26134
Dissolved Oxygen	-0.2825	-0.0419
PH	0.0166	-0.4493
TDS	-0.4340	-0.3788
Secchi depth	0.5950	0.04118
Conductivity	-0.300	0.0868
Salinity	-7.690	1.057

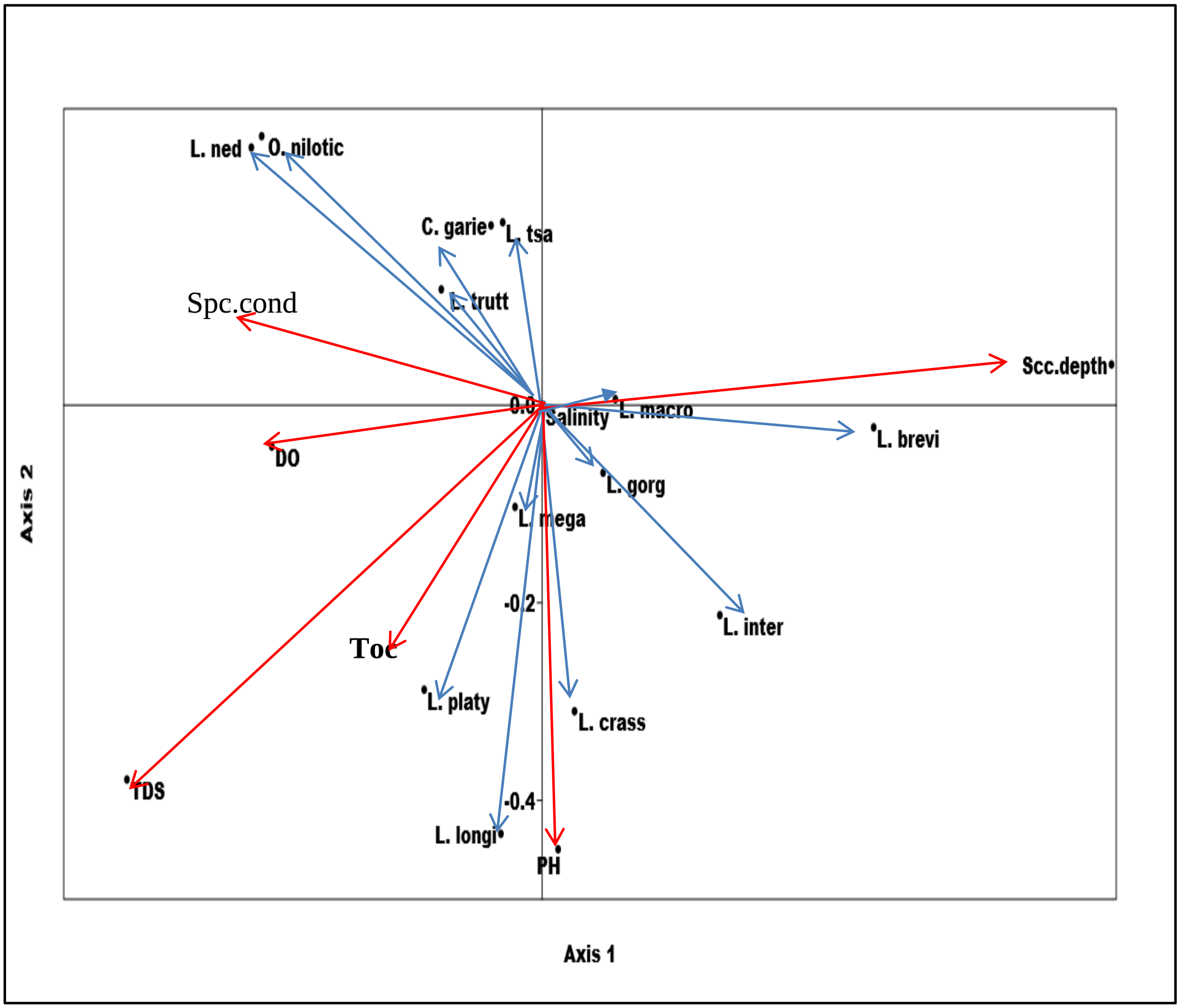

Figure 3. The RDA of biplot physico-chemical parameters vs. fish species distribution in the western part of Lake Tana

Abbreviation: *C. garie- Clarias gariepinus, L. brevi- Labeobarbus brevicephalus, L. crass- Labeobarbus crassibarbis, L. gorg- Labeobarbus gorgorensis, L. inter- Labeobarbus intermedius, L. ned- Labeobarbus nedgia, L. platy- Labeobarbus platydorsus, L. trutt- Labeobarbus truttiformis, L. tsa- Labeobarbus tsanensis, L. longi- Labeobarbus longissimus, L. macro-Labeobarbus macrophthalmus, L. mega- Labeobarbus megastoma and O. nilotic- Oreochromis niloticus.*

The second axis which showed 18.16 % of variance was negatively correlated with environmental variance (Table 10). Secchi depth was positively associated with the second axis (Fig. 3). Conductivity was positively associated with *C. gariepinus*, *L. nedgia*, *L. truttiformis*, *L. tsanensis* and *O. niloticus* in the second axis. The remaining species (*L. longissimus*, *L. megastoma* and *L. platydorsus*) were negatively correlated with TDS, dissolved oxygen and temperature in the second axis. In agreement with Sebastian-Gonzalez and Green (2014) the vector length of a variable represents the relative importance of that variable for predicting the fish assemblage composition. The vectors can be extended in either direction to identify the position of a species relative on other species along that gradient (Ter Braak, 1986 and Felgush Erarto *et al*., 2020). On the other hand, 72 % of the relation was associated with anthropogenic factors might be overfishing and using destructive fishing gears.

4.5. Shannon diversity index and evenness of fishes

4.5.1. Shannon diversity index and evenness in fishes of the western part of Lake Tana

Three families and 13 species were recorded with a total of 6118 fish specimens that were collected during this study period. The fish species diversity in the western part of Lake Tana was (H' = 1.6) (Table 11). The H' value of the present study is compared to Lake Tana sub-basin (Gumara River) (H'=1.21) Felegush Erarto *et al*. (2020), Rib river mouth (H'= 0.63) Yeshzerf Shumye (2016), Lake Zeway (H' = 1.51 to 1.67) Lemma Abera (2016) and Blue Nile River (8 spp.; H'=1.23 to 1.64) Tadlo Awoke *et al.* (2015). The lower fish diversity in the lake is due to the destruction of breeding area, use destructive fishing gears through human encroachment (Lemma Abera, 2016). Hence, results of our study showed that the decline of the fish may be correlated with anthropogenic activities. According to Sheldon (1969) and Felegush Erarto *et al*. (2020) when the (J') value is getting close to 1; it means that the individuals are distributed evenly among all of the species in the sample. Evenness value of our study (J'=0.62) indicated that there is not uniform distribution of individuals among the species (Table 11). According Ulfah *et al*. (2019) the high diversity value is due to the abundance of fish species and the low diversity value is due to the absence of fish species that dominate in these waters.

Table 11. Shannon diversity index and evenness value in the western part of Lake Tana

Species	**N**	**Pi**	**lnpi**	**Pi*lnPi**	**H’**	**Evenness (J)**
Clarias gariepinus	1737	0.28	-1.26	-0.357	1.6	0.62
Labeobarbus brevicephalus	81	0.01	-4.32	-0.057		
Labeobarbus crassibarbis	79	0.01	-4.35	-0.056		
Labeobarbus gorgorensis	37	0.01	-5.11	-0.031		
Labeobarbus intermedius	508	0.08	-2.49	-0.207		
Labeobarbus longissimus	129	0.02	-3.86	-0.081		
Labeobarbus macrophtalmus	58	0.01	-4.66	-0.044		
Labeobarbus megastoma	111	0.02	-4.01	-0.073		
Labeobarbus nedgia	108	0.02	-4.04	-0.071		
Labeobarbus platydorsus	234	0.04	-3.26	-0.125		
Labeobarbus truttiformis	126	0.02	-3.88	-0.080		
Labeobarbus tsanensis	81	0.01	-4.32	-0.057		
Oreochromis niloticus	2829	0.46	-0.77	-0.357		
Total	**6118**					

4.5.2. Differences in Shannon diversity index and evenness among the sampling sites

The diversity of fish depends on the influence on the physico- chemical factors and availability of fish feed, fish assemblage and other anthropogenic factors. Among the three sampling sites, the highest diversity was recorded at Kunzila (H’=1.74) and the lowest was recorded at Delgi (13 spp. H’=1.55) during the present study (Table 12; Appendix 6 & 7). The highest evenness value of fish was recorded at Kunzila (J’=0.70) (Appendix 6) and the lowest value of fish was recorded at Delgi (J’=0.60). The diversity index value at Dengelber was (H’=1.58) (Table 12 & Appendix 8). The highest evenness value of this site may be contributed as a result of, majority of fishermen at Kunzila were used multifilament gears (>8cm mesh size). According to own observation during the research period, a large portion of fishermen at Delgi were set their fishing gears near to the shore of the lake during the breeding time. The government should be prohibited to control fishing the fishers at the shore of the Lake and restricted the number of fishing gears and mesh size.

This may be cause of fish decline. On the other hand, the vegetation coverage on the shore of the lake was very poor in Delgi site compared to the other sites. The differences in fish diversity and abundance in the sites might be associated with the differences in habitat type, volume of water and vegetation cover of the area in addition to the efficiency of fishing gears and the extent of fishing effort exerted for sampling during the study period (Tesfaye Melak and Abebe Getahun, 2012).

Table 12. Number of species (N) diversity index (H') and (J) evenness for fish caught at sampling sites.

Sampling sites	**Kunzila**	**Dengelber**	**Delgi**
H	1.74	1.58	1.55
J	0.70	0.64	0.60
N	12	12	13

4.5.3. Differences in Shannon diversity index and evenness between wet and dry seasons

The value of Shannon's diversity index was (H'=1.60) and (H'=1.81) at Kunzila during dry and wet season, respectively (Table 13). The species diversity was also higher in the wet season (H´=1.60) than dry season (H´=1.3) at the site of Dengeber, whereas, the diversity index value of the site of Delgi was similar in the wet and dry seasons. The highest evenness value in the western part of Lake Tana was recorded at Kunzila during the wet season (J'=0.73) and the lowest value was recorded at Dengelber during the dry season (J'=0.54). The variation of the Shannon diversity index and evenness differences between wet and dry seasons in the study area might be due to variation of abiotic factors and gill net efficiency in the catch. This is similar to findings of Zeleke Berie (2007) in which difference of fish diversity between Beles and Gilgel Beles Rivers was found to be due to variation of available habitats, fishing effort, fish behavior and size of fishes.

Table 13. Number of species (N) and diversity index (H') for fish caught during wet and dry seasons.

Sampling sites	Kunzila		Dengelber		Delgi	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
H	1.60	1.81	1.3	1.60	1.50	1.53
J	0.64	0.73	0.54	0.64	0.63	0.62
N	12	12	11	12	11	12

4.6. Socio- economics of the fisheries in the western part of Lake Tana

4.6.1. Socio-demographic characteristics

The socio-demographic characteristics in the western part of Lake Tana, such as gender, age, religion, marital status, household size and educational background of the respondents are presented in Table 14. A total of 197 fishermen (98% (n=193) males and 2% (n=4) females) were interviewed for the present study. The number of female fishermen in the study area was very low. This is due to the culture of the community in which priority is given for males' in a gender based labor division. This result is similar to the report of Dereje Tewabe (2014) on Lake Tana; Erkie Asmare *at al*. (2016) on Jemma and Wonchit Rivers; Shewit Gebremedhin *et al*. (2013) on Lake Tana and Mathewos Temesgen (2017) on Lake Langeno. Even though, the numbers of female fishermen respondents were very low in the study area, they participated in fish processing and marketing system. About 175 (88.8%) of them were married and have families and the remaining 8.6% were single and 2.5% were divorced. Married house head groups dominated the marital status of respondents. This might be due to the burden and responsibilities, they have in their families to cover expenses of their children‘s health, education and basic needs held by Mathewos Temesgen (2017). The majority of the respondents were followers of Christian Orthodox religion (93.9%) and 6.1% were Muslims.

According to the respondents, 65% of them have family size greater than 6. Educational status of the respondents also showed that 35.5% were illiterate and 64.5 % of them have received formal education, such as 1-4 (39.6%), 5-8 (17.6%), 9-10 (9.6%) and 11-12 (0.5%). This shows that the fishing activity is not only for illiterate and poor communities, but also for students and others get a job opportunity (Aytegeb Anteneh, 2013, and Kidanie Misganaw and Addis Getu, 2016). The level of education in the western part of Lake Tana indicated that fishing practice is important for better understanding of policies, management implications and to facilitate collaboration with concerned bodies (Alamrew Eyayu, 2019). Most of the respondents (62.4%) were about 31-40 years old.

Table 14. Summary of socio-demographic features of the fishermen respondents in the western part of Lake Tana, Ethiopia from December 2019 to February 2020.

Socio-demography	**Category**	**Total**	**Percent (%)**
Gender	Male	193	98
	Female	4	2
Marital status	Single	17	8.6
	Married	175	88.8
	Divorced	5	2.5
Age	14-20	1	0.5
	21-30	32	16.2
	31-40	123	62.4
	41-50	35	17.8
	>50	6	3
Religion	Christian-Orthodox	185	93.9
	Muslim	12	6.1
Household family size	<3	29	14.7
	4-5	40	20.3
	6-8	80	40.6
	9-11	33	16.8
	>12	13	7.6
	Non educated	70	53.5
Educational level	1-4	78	39.8
	5-8	29	14.7
	9-10	19	9.6
	11-12	1	0.5

4.6.2. Categorization of fishers

The analysis showed that the fishery respondents in the western part of Lake Tana were categorized into 41.1% full-time, 48.7 % part- time and 10.2 % seasonal fishermen as presented in Table 15. The majority of respondents in the western part of Lake Tana were part- time fishers. This is similar to findings of Shewit Gebremedhin *et al*. (2013) on Lake Tana (63.8%), Mathewos Temesgen (2017) on Lake Langeno (61.7%), Alamrew Eyayu (2019) 62.8% on Ayima River and on the lower Omo River and the Ethiopian part of Lake Turkana (74%) in which the majority of the fishers were part-timers (Mulugeta Wakjira, 2016). The part-time fishers depend on alternative means of livelihoods such as agriculture, labor employment and trade. In contrast, Dagninet Amare *et al*. (2018) has reported that on Lake Tana 14.6% were part-time and 58.5% were full time fishers. The reason for the presence of majority part-time fishermen in the study area was due to the accessibility of agricultural land (Alamrew Eyayu 2019). In Africa and parts of Asia, part-time fishers often alternate seasonally between fishing and other occupations, such as agricultural laboring (Welcomme, 1985). It is also reported that part-time fishers usually combine fishing activity with other livelihoods and it is especially common in the tropics (FAO, 2014 and Alamrew Eyayu, 2019).

The frequency of fishing in the study area was 4-5 days per week had with an average of 41.6% coverage. This indicated that most of the fishermen are part time fishers and had other means of livelihoods. The majority of the respondents (66%) had fishing experience for more than 10 years. The fishing types of the respondents in the study area were fishing alone (87.8%) and in groups 12.2%. This result is different from Mathewos Temesgen (2017) in which 45.0 % were fishing in groups on Lake Langeno.

Table 15. Fishing activities, frequency of fishing per week and experience of fishing by respondents in the western part of Lake Tana, Ethiopia from December 2019 to February 2020 at $P<0.05$, Chi-square test is statistically significant ($P<0.05$).

Fishing activities	**Category**	Chi-square value			**Percent (%)**	**p-value**
		Kunzila	**Dengelber**	**Delgi**		
Fishers categories	Full time	28.4	23.4	29.2	41.1	0.008
	Part -time	33.6	27.8	34.6	48.7	
	Occasional	7	5.8	7.2	10.2	
Frequency of fishing (days per week)	Daily	28.4	23.4	29.2	41.1	0.012
	1-3daysper week	4.6	3.8	4.7	6.6	
	4-5 days per week	29.6	24	29.9	42.1	
	Occasional	7	5.8	7.2	10.2	
Fishing experience	1-5 years	3.9	3.2	4	5.6	0.00
	6- 10 years	19.6	16.2	20.2	28.4	
	11-15 years	21.7	17.9	22.3	31.5	
	16-20 years	12.6	10.4	13	18.3	
	21-30 years	6.7	5.5	6.8	9.6	
	>30 years	4.7	3.8	4.7	6.6	
Types of fishing	Fishing alone	60.6	50.1	62.4	87.8	0.00
	Fishing in groups	8.4	6.9	8.6	12.2	

4.6.3. Fishery enterprise and fishermen associations in the study area

The majority of fishermen in the western part Lake Tana were fishing individually. However, during the study period, the total number of members of the fishermen enterprise was 14 and fishermen associations were 85 (Table 16). Out of the total number, 12.2 % were from fishery enterprise and fishermen's association and 87.8% were from individual fishermen. The fishermen associations were organized by the donation of BDU, NABU and AGP. BDU organized two fishermen associations at Kunzila and Estumit Kebeles. AGP also organized one fishermen association at Dengelber Kebele.

They donated to construct shopping house, fishing materials (such as refrigerator, balance and knife), fishing gears and two motorized boats. The boats were donated to Kunzila and Estumit fishermen's association. Refrigerators were donated by AGP for all fishermen association. In the present study, all the respondents had fishing license. On the other hand, more than 156 fishermen have no fishing license in the three Woredas. According to key informant interview the fishermen who had not fishing license were considered as illegal fishermen. According to the respondents the government provided access to credit for fishermen to increase fish production. However, there are only four fishermen enterprises and three fishermen associations that were organized with the support of government in the three Woredas: one for only females and two for both sexes. The female association was organized for the purpose of fish processing.

Table 16. Fishermen enterprise and members of fishermen association in the study area

Districts	**Kebeles**	**Enterprise of Fishermen**			**Fishermen Association**		
		Male	**Female**	**Total**	**Male**	**Female**	**Total**
North Achefer	Kunzila	2	-	2	35	8	43
	Estumite	-	-	-	21	11	32
Alefa	Dengelber	4	1	5	-	10	10
	Eseydebir	4	-	4			
Takusa	Delgi	3	-	3			

4.6.4. Catch composition

The catch composition in the western part of Lake Tana includes *O. niloticus*, *C. gariepinus* and *Labeobarbus* fish species. In the present study, fish catch compositions were different from season to season in the study area (Fig.4). According to the respondents the catch compositions in the study area were *O. niloticus* (31%), *C. gariepinus* (56.3%) and *Labeobarbus* spp. (12.7%) during summer season. *Orochromicus niloticus* (68.5%), *C. gariepinus* (8.6%) and *Labeobarbus* spp. (22.8%) were caught during autumn. This is similar to the findings of Shewit Gebremedhin (2013) the catch composition of *O. niloticus* was highest from December to April and lowest in rainy season.

This might be due to the abundant growth of macrophytes during the rainy season in the littoral zone of the lake, to which the Nile tilapia move for breeding and hiding from predators. As it is very difficult to set gill nets in this habitat, fishers could not harvest them. The catch compositions of fish during winter time were *O. niloticus* (35%), *C. gariepinus* (16.8%) and *Labeobarbus* spp. (48.2%). The remaining catch compositions during spring were *O. niloticus* (39.6%), *C. gariepinus*

(35%) and *Labeobarbus* spp (25.4%). Generally, the respondents showed that the total catches were *O. niloticus* (54.3%), *C. gariepinus* (23.4%) and *Labeobarbus* spp. (22.3%) fish catch composition in the study area (Fig. 5). According to Abebe Getahun *et al*. (2008) the catch composition in Lake Tana constitute Nile tilapia (64%), Catfish (21%) and *Labeobarbus* spp. (15%). In a similar study, the catch composition of fish species in Lake Tana was 50%, 30% and 20% of Nile tilapia, *Labeobarbus* species and Catfish, respectively (Kidanie Misganaw and Addis Getu,2016). The catch composition of endemic *Labeobarbus* species was high compared to the previous studies. This might be due to the presence of high customer demand of these species and the *Labeobarbus* species was the main targeted species in the fishery production as a result of the high market price at the landing sites particularly at Kunzila.

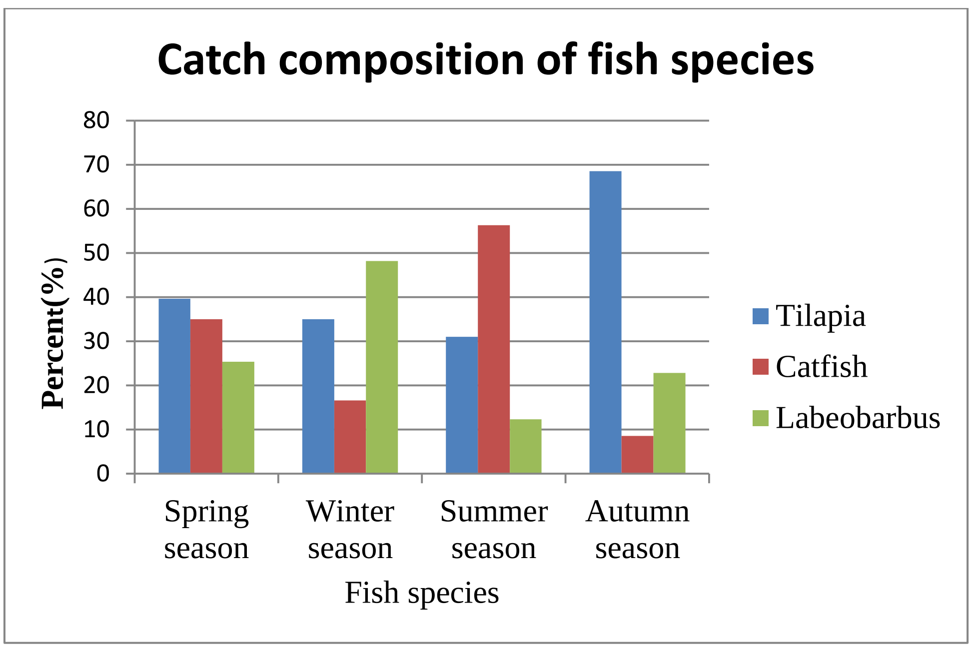

Figure 4. The variation of fish catch composition in seasons in the study area

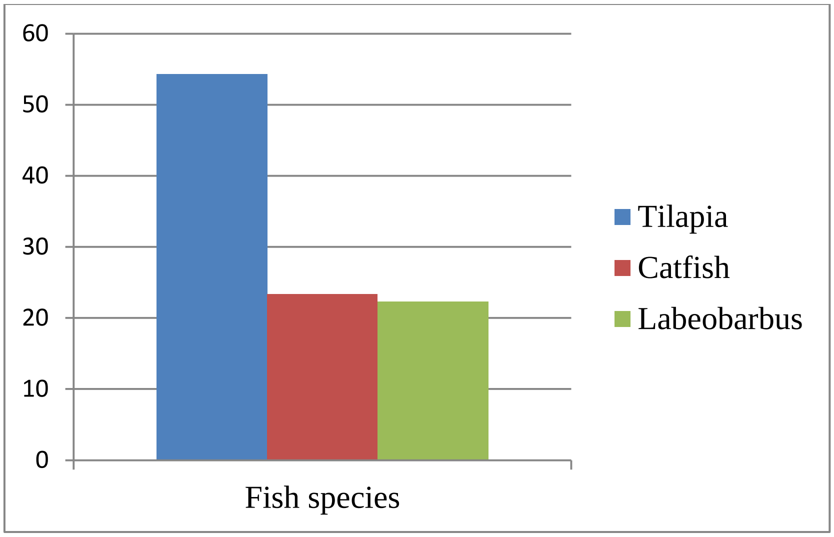

Figure 5. The catch compositions of fish in the western part of Lake Tana

4.6.5. Livelihood backgrounds of the fishing community

Fish is the main food source for people in the study area. The main livelihood sources of the interviewed fishermen were fishery, field crop, livestock, daily labor and trade. The respondents indicated that 40.6% of them depend on fishing activities only while fishing and livestock rearing, fishing and field crop, fishing and daily labor and fishing and trade constituted 10.2%, 34.8%, 9.1% and 5.1%, respectively (Fig.6). Similarly, both farming and fishing are the most important activities for food supply and serve as a source of income in some parts of Ethiopia (Erkie Asmare, 2016; Mulugeta Wakjira, 2016, Dagninet Amare *et al.* 2018 and Alamrew Eyayu, 2019). According to Lemma Abera (2016) the majority of females in Lake Ziway fishery participated in the activity of livestock rearing, and they were involved in fishery related business like preparing food for the fishermen around the fish landing sites. The majority of women fishers were engaged in fish post harvesting and fish filleting at the landing sites.

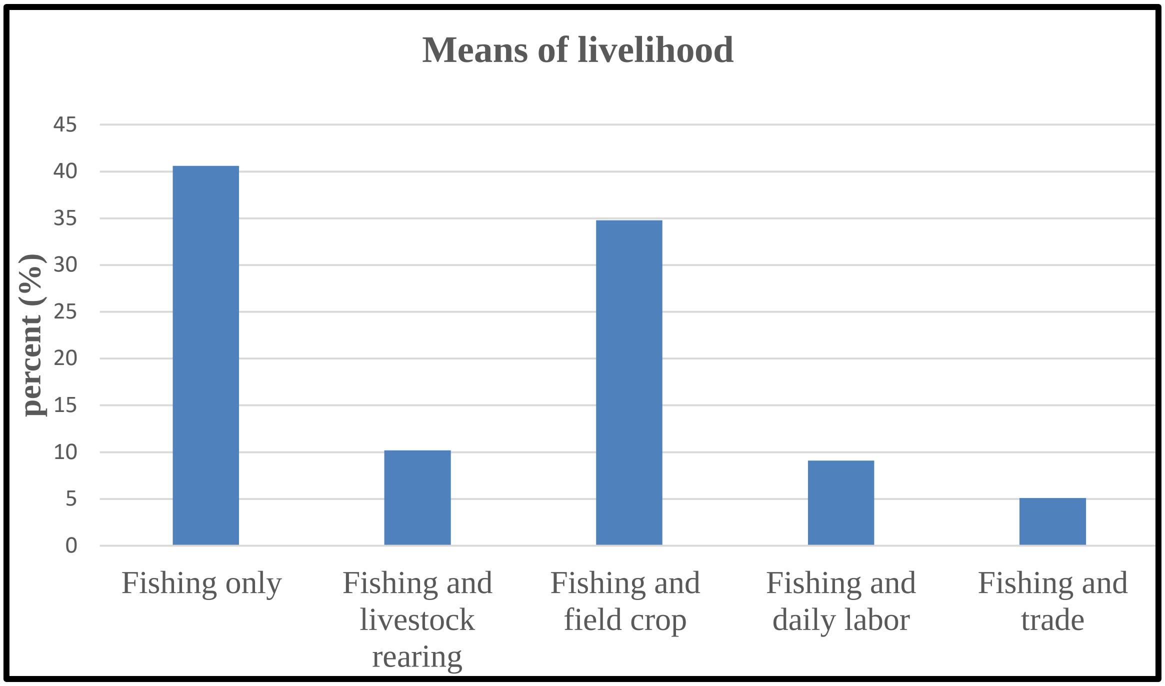

Figure 6. The livelihood backgrounds of the fishermen in the study area

4.6.6. Possession of fishing gears and boats

The fishery in Lake Tana is characterized by a specific combination of fishing gears and fishing boats (Table 17). Lake Tana fishers have different fishing gears with different types and mesh sizes of gill nets, hooks and lines, cast net, fish traps and different locally made fish gutting and filleting materials. Of the total of 197 fishermen interviewed, 98 % of them had fishing gears and boats. The majority of fishermen used monofilament gill nets (64%) which is imported from Sudan and only 36% used multifilament gillnets. This might be due to the price of monofilament nets which was very low compared to multifilament nets and monofilament nets are more "efficient" than multifilament nets. The price of monofilament gill nets (50 m length and 2.5 m depth) was 250-300 ETB while the price of multifilament (100m length and a depth of 2.5m) was 1750-2000 ETB. Most of multifilament gill net users prepare their fishing gears themselves. However, the price of multifilament gill net was more than 3000 ETB when they bought from gear makers.

The minimum number of fishing gear set per day in the whole lake was 4 and the maximum was 55 which were set by fishermen association. The majority of multifilament gillnets were owned by fishermen association. BDU in collaboration with NABU and AGP has donated two motorized boats and 38 multifilament gill nets fishermen associations. The first association was Kunzila fishermen and the second was Estumit fishermen association. They donated one motorized boat and 19 multifilament gill nets for each association. The total number of fishing gears operating on the Lake Tana is also increasing dramatically. According to Shewit Gebremedhin (2013) the average number of monofilament nets were 6 set individually per day in Lake Tana. However, in the present study, the average number of gears set per day was 10 and 47% the fishermen used mesh sizes below 8cm. The majority of respondents (89.6%) owned traditional (reed boat), whereas, only 10.4% used motorized boats. This indicated the presence of increased commercial gillnet fisheries and there is high fishing pressure in the study area. There are four fishermen enterprises that owned motorized boats, which is supported by the government by providing finance through the ACSI (Amhara Credit and Saving Institution). Generally, the increase in fishing gears indicated the increasing human pressure (Mberengwa and Zelalem Bacha, 2011).

Table 17. Fishing gears and boats possession by respondents

Fishing activities		**No**	**Percent (%)**	**P -value**
Type of fishing gears	Multifilament	61	31.6	0.00
	Monofilaments	107	55.4	
	Multifilament and hooks and lines	8	4.1	
	Monofilament and hooks and lines	17	8.8	
Types of boats	Motorized boat	22	10.4	0.00
	Reed boat (Tankua)	173	89.6	

4.6.7. Socio-economic contribution of fisheries

4.6.7.1. Role of fishing

The respondents showed that most of the fishermen were fishing for the purpose of consumption as well as for income (Fig. 7). The results indicated that fishing for both consumption and sale were 92.8 %, 97.2 % and 94.7% at Kunzila, Delgi and Dengelber, respectively. Fish products only for selling accounts for 7.2%, 2.8 % and 5.3 % in Kunzila, Delgi and Dengelber, respectively.

The contribution of fishing in the study area was similar to that of Lake Ziway in which, fish can be consumed at the household level (direct contribution); the indirect contribution area was that fishermen sell the fish products and in turn buy other food items for home consumption and other purposes (Lemma Abera, 2016). Most girls and boys were engaged in fish filleting. When consumers bought a whole fish from the fishermen at fish landing sites, they paid additional income for fishermen. Consumers paid 10-15 ETB for one fish when processed depending on the size of fish species. These were sources of job opportunity for many unemployment girls and boys, mainly at Kunzila and Delgi landing sites. They earned more than 50 ETB per person per day.

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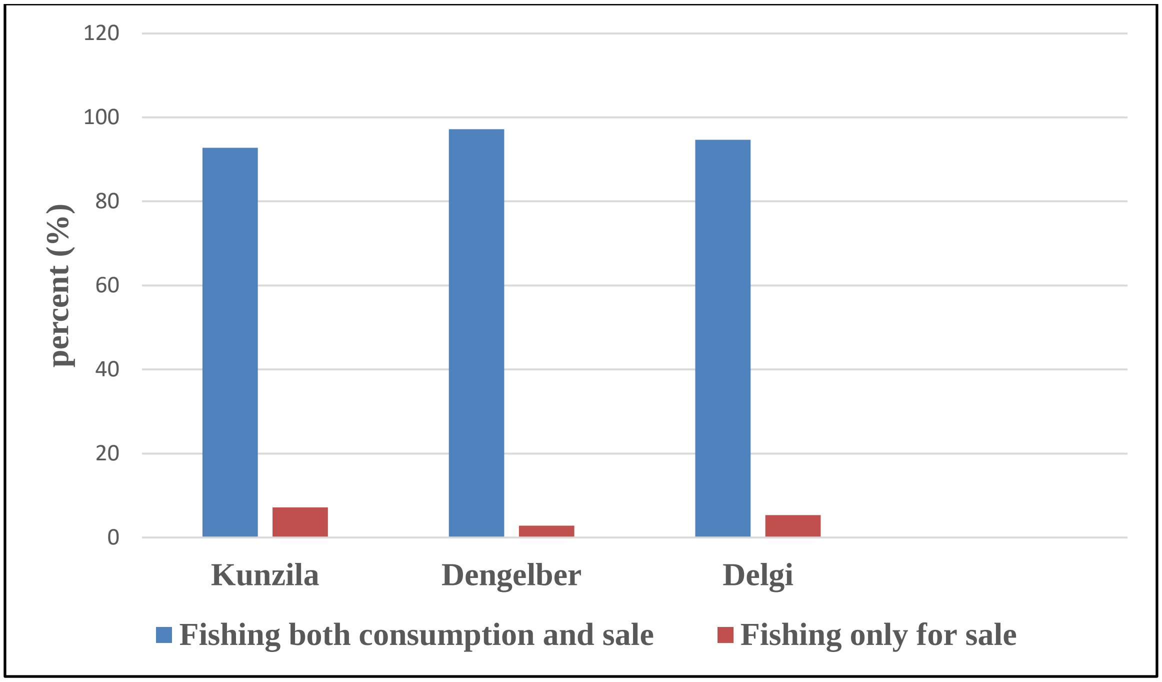

Figure 7. The role of fishing in the study area

4.6.7.2. The income of fishermen from fishing activities in the western part of Lake Tana

The respondents showed that the income of fishermen was from fishing activities in the study area (Table 18). From the total of 197 respondents 81 were fishing daily and only 20 were occasional fishermen. The average monthly income for daily and occasional fishers' was 2487.65 and 1322.00 ETB, respectively. This result was similarly with the findings of Shewit Gebremedhin *et a*l. (2013) which indicated that fishermen performing daily fishing activities are earning almost twice as much income as occasional fishers from Lake Tana. Out of the 197 fishermen, 36 of them had more income whose fishing experience was 16-20 years. The maximum average monthly income was 2298.61 ETB by those whose fishing experience was16-20 years and the minimum income was 1372.73 ETB earned by those having 1-5 years of fishing experience. This indicated that fishing activities need more experience similar to other works.

Fishing is not necessarily requiring educated persons, but skills developed as a result of experience are still mandatory to operate and manage fishing activities (Alamrew Eyayu, 2019). It has been found that full time fishers earned 2485.95 ETB per month in the western part of Lake Tana fisheries while the part-time fishermen and occasional fishermen earned 1869.27 and 1322.00 ETB per month respectively. This indicated that the income of fishermen increase when the fishing duration increases due to increased fishing effort. This is similar to the report of Mathewos Temegen (2017) in Lake Langeno in which full-time fishermen are investing most of their time in fishing as an important part of their daily livelihood and had more income and fishing is serving as the major means of livelihood.

The majority the respondents (173) were fishing alone and the remaining (24) were fishing in groups. The fishermen who fished alone and those in groups in the western part of Lake Tana had an average monthly income of 1907.75 and 3210.42 ETB, respectively. The highest income secured by fishers in cooperative organizations, compared to the individual fishers, may also highlight the necessity of strengthening organizations and collective action in small scale fisheries (SSFs) to ensure their contributions to fishers' livelihood (FAO, 2014 and Mulugeta Wakjira, 2016). There was a significant income difference between fishing alone and fishing in groups.

In the present study, the average monthly income, for those, who owned modern and traditional boats were 3300.00 and 1907.75 ETB, respectively. There was a significant income difference between modernized boat and traditional boat (Papyrus reed boat). The fishermen who had motorized boats had got more income than those operating with traditional boats (Papyrus reed boat). This might be due to the motorized boat fishermen were used essentially the bigger multifilament gill nets and cover large areas as compared to traditional boats. On the other hand, all reed boat fishermen do not go for fishing far from the shore of the lake (Aragaw Chalachew, 2011). Shewit Gebremedhin *et al*. (2013) reported that the number of fishing equipment that fishermen own determines the level of their income from Lake Tana. Fisheries in the western part of Lake Tana are largely dependent on local wooden boats such as reed boats.

Table 18. The mean monthly income of fishermen (ETB) related to fishing frequency, type of boat and fishing activities.

Fishing activities	**Mean**	**N**	**Std. Error**
Fishing frequency			
1-3 days per week	1850.00	13	216.913
4-5 days per week	1868.67	83	51.249
Occasional	1322.00	20	87.8537
Daily	2487.65	81	71.974
Average	**2066.45**	**197**	**48.554**
Fishing experience			
1-5	1372.73	11	133.887
6-10	1761.43	56	66.503
11-15	2251.61	62	93.644
16-20	2298.61	36	104.245
21-30	2236.84	19	193.303
>30	2192.31	13	54.844
Average	**2066.45**	**197**	**48.554**
Categorization of fishing			
Full time fishermen	2483.95	81	72.189
Part time fishermen	1869.27	96	52.763
Occasional fishermen	1322.00	20	87.853
Average	**2066.45**	**197**	**48.554**
Type of boat			
Modernized boat	3300.00	22	119.704
Reed boat (Tankua)	1907.75	173	38.885
Average	**2064.82**	**195**	**48.625**
Fishing activities			
Fishing alone	1907.75	173	38.885
Fishing in groups	3210.42	24	136.400
Average	**2066.45**	**197**	**48.554**

4.6.7.3. Association of fishers' income with demographic variables and fishing activities

Association of fishers' income with variables of age, education, family size, fishing frequency, fishing experience, number of gears set per day, distance to market and types of fishing gears were presented in Table 19. In total 9 variables were investigated and the total number of cells in the correlation matrix is 36. Out of the total cells, 66.6 % were significantly associated with each other. Age of respondents ($R=0.114$, $P< 0.01$), education (R=0 0.049, $P<0.01$), family size ($R=0.120$, $P<0.01$), fishing frequency ($R= 0.404$, $P<0.01$), fishing experience ($R= 0.304$, $P<0.01$) and number of gears set per day ($R=0.349$, $P<0.01$) were positively associated with fishers income. However, distance to market ($R=-0.120$, $P<0.01$) and types of fishing gears ($R=-0.072$, $P<0.01$) were negatively associated with fishers income. As the age of the fishers increased, their physical assets, their knowledge and skill of fishing increased and thus, the income of fishers increased. Similarly, a high proportion of active age groups in fishing might be taken as a proof that fishing is an intensive activity that requires a strong workforce (Alamrew Eyayu, 2019). On the other hand, the aged ones show lesser tendencies to stay in fishing activities since fishing demands more energy and more time to stay along the fishing grounds searching for fish (Alamrew Eyayu, 2019). The level of education is positively correlated with the income. This might be due to the fact that level of education enables fishers to understand the technical requirements of fish capture and skills which could be support as a result of experience. Fishing frequency is positively associated with the total income of the fisherman in the study area. Number of gears set per day was also positively correlated with income of fishers. This is associated with the condition that the large number of gears set the more fishes caught. Distance from market was negatively associated with fishers' income. This is probably due to high fish post-harvest loss that occurs when the distance to the market is longer (Shewit Gebremedhin, 2013). The size of fishing gears were negatively associated with fishers' income. This might be due to the fact that the smaller the size of gears, the smaller the size of fishes caught. Thus, the demand and the price of small sized fish is lower as compared to the larger ones.

Table 19. Pearson's correlation analysis (R) of income with explanatory variables, significance levels (2-tailed): $P \leq 0.01$ is significant.

No	Explanatory variables	1	2	3	4	5	6	7	8	9
1	Income (1)	1								
2	Age (2)	0.114	1							
3	Education (3)	0 .049	0.076	1						
4	Fishing frequency (4)	0.404**	0.034	0.025	1					
5	Fishing experience (5)	0.304**	0.497**	-0.062	0.000	1				
6	Number of gears set per day (6)	0.349**	-0.076	0.079	0.144*	-0.054	1	.		
7	Distance to market (Km) (7)	-0.120	0.033	0.117	0.115	-0.275**	-0.152*	1		
8	Family size (8)	0.120	0.697**	-0.024	-0.004	0.415**	-0.011	0.100	1	
9	Types of fishing gears (9)	-0.072	-0.123	-0.067	0.053	-0.170*	0.199**	-0.012	-0.165*	1

4.6.8. Marketing system in the western part of Lake Tana

4.6.8.1. Marketing of fish

The Ethiopian domestic fish consumption pattern around water bodies is no different from what is observed globally. The price of whole fish and filleted fish of *O. niloticus*, *C. gariepinus* and *Labeobarbus* in the three districts are presented in Table 20. The price of fish in the study areas fluctuates depending on differences in fish species, fish size, season, religion practice and distance from market. *Oreochromis niloticus* had higher price at the district of Takusa among the three districts. The price of tilapia in this woreda was 45-60 ETB/kg for a whole fish and 55-80 ETB for filleted fish. This is due to the demand from customers, local restaurants, hotels and cafes which were higher relative to the other sites. This is similar to the finding of Lemma Abera (2016) in which *Oreochromis niloticus* obtained a higher price than other fish species because it had higher demand from the customers in Lake Zeway fisheries. The price of *Labeobarbus* spp. was higher at North Achefer and Alefa districts.

The price of *Labeobarbus* was 40-60 ETB/kg for whole fish and 50-90 ETB/kg for filleted fish in the North Achefer woreda. The price of these species at Alefa woreda was 45-70 ETB/kg for whole fish and 50-80 ETB/kg for filleted fish. The fish price was high before or after the Orthodox Christian Lent seasons and in the non-fasting seasons. However, the price of *Clarias gariepinus* was low in the three districts compared to other species. This is because *Clarias gariepinus* was not a preferred species within the community for consumption. The majority of Orthodox Christian followers accepted that catfish is prohibited from being consumed. The price of filleted fish is higher compared to whole fish at all sampling sites. The price of whole fish varies according to their size and the type fish species. According to Aytegeb Anteneh (2013) the price of whole tilapia was 10.0 ETB/kg and, *Labeobarbus* spp. was 5.50ETB/kg and catfish was 5.75ETB/kg in Lake Tana fisheries. Currently, the price of both filleted and whole fish is extremely increased as compared to the last ten years.

Table 20. The price of fishes during fasting and non-fasting times at the landing sites in the western part of Lake Tana.

Variables	**Districts**					
	North Achefer		**Alefa**		**Takusa**	
	FD	**NFD**	**FD**	**NFD**	**FD**	**NFD**
Oreochromis niloticus						
Whole fish price (Birr/kg)	20 -30	35-40	25-30	35-50	30-40	45-60
Filleted (Birr/kg)	30-35	40-50	35-40	45-70	45-50	55-80
Clarias gariepinus						
Whole fish price (Birr/kg)	15-20	22-30	20-25	25-30	20-25	30-35
Filleted (Birr/kg)	22-30	30-35	28-35	33 -35	30-35	30-40
Labeobarbus spp.						
Whole fish price (Birr/kg)	20 -30	40-60	15-25	45-70	15-20	30-35
Filleted (Birr/kg)	30-35	50-90	30-35	50-80	20-35	30-45

In the study area fish marketing system starts at landing sites. The respondents showed that fish product marketing system in the study area included direct to individuals only (30%), individuals and traders (44.7%), local outlets (cafeterias, hotels & restaurants) (17.8%) and fishermen's association (7.6%) (Fig. 8). The largest portion of fish marketing system was that sold directly to individuals and traders in the study area. The majority of individual fishermen sold their fish products, particularly *Oreochromis niloticus* and *Labeobarbus* directly to individuals and local outlets (cafeterias, hotels and restaurants) at landing sites. This is due to lack of fish processing materials at landing sites and the fishermen have to immediately sell their products to consumers. However, the fishermen sold catfish directly to traders and fishermen associations.

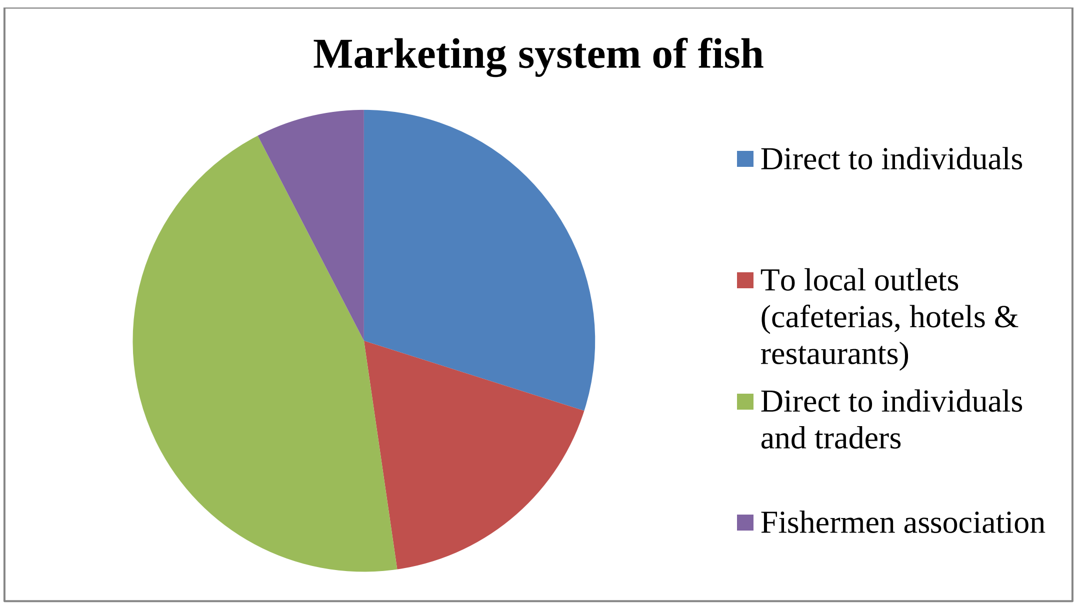

Figure 8. Fish market outlets in the study area

In the present study, the fish products were sold as whole fish (33.5%), processed (21.3%) and both whole fish and processed (45.2%) (Fig. 9). The majority of fishermen, wholesale fish products in the form of both whole fish and processed. Most fishermen sold the filleted fish products to the consumer during non-fasting periods. This is because the customers need fresh fish at landing sites. However, more whole fish were sold to the consumers at Kunzila and Delgi landing sites. The fishermen sold whole fish when the landing site was near to the market and filleted when the landing site was far from the market. The majority of fishermen sold catfish as processed form (sun-dried) to fishermen associations and traders in the study area. A large portion of processed fish was sold during fasting periods to traders and fishermen associations. In the study area demand of fish is low during the Orthodox Christian fasting days (Wednesdays and Fridays) and fasting periods (55 days in March/April, 15 days in August).

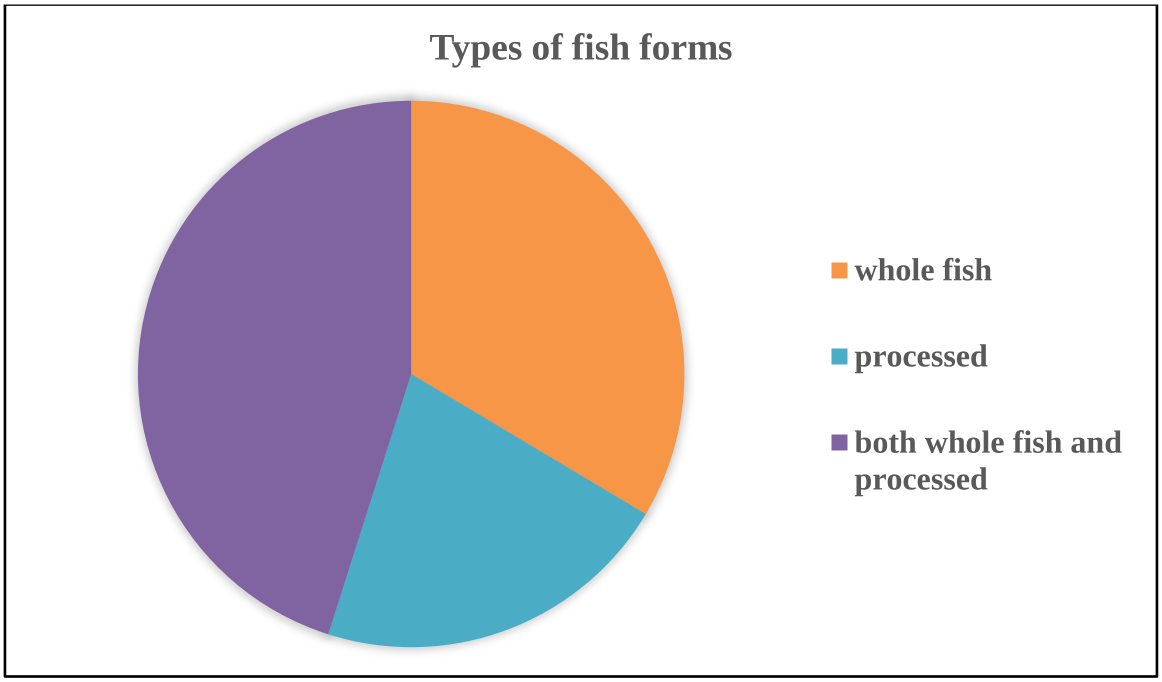

Figure 9. Types of fish forms presented in the market system in the western part of Lake Tana

4.6.8.2. Market and value-chain of fishery

The value chains in the fish market in the western part of Lake Tana were included in the regional and national networks (Fig.10). In the study area fish consumption and marketing system start at landing sites. The major routes of fish markets are towards the surrounding towns such as Kunzila, Liben, Dengelber, Eseydebir, Shahura, Astedemariyam, Dikularba and Delgi. Fishermen's Association and individual fish traders accepted fish from fishermen and bring to different towns.

The majority of fish products were sold in the nearby markets by the illegal fish traders. According to the report of Assefa Mitike (2016) and Mathewos Temesgen (2016) major fish market was taking place at the landing sites with lower price. High quantity of fish products were supplied during non-fasting season and days in the study area. This is because most of the residents of the western part of Lake Tana are Orthodox Christians and they accepted that fish is a kind of animal meat and it is prohibited to eat during fasting days. This result contradicts with the report of Assefa Mitike (2016) and Mathewos Temesgen (2017) in which it was reported that more fish products were provided for consumers during a fasting season.

The second market route involved Bahir Dar and Gondar by fishermen enterprise and fishermen's association. *Oreochromis niloticus* and *Labeobarbus* species were distributed with high demand to the surrounding towns of Bahirdar and Gondar. According to the information obtained from the fishermen and own observation, there is a high market demand of fish at landing sites, particularly *O. niloticus* at the site of Delgi and *Labeobarbus* species at Kunzila during non-fasting days. The third market route was to Metema, which is the border town near Sudan and Addis Ababa, the capital city of the country. *Clarias gariepinus* was the most exported fish species to Sudan as dried fish. This was mainly taking place by individual traders and fishermen associations. This is similar to findings of Aytegeb Anteneh (2013) in which it was mentioned that without any stringent and quality control Ethiopia exports dried fish from Lake Tana to Sudan. *Oreochromis niloticus* was the major fish species also transported to Addis Ababa through FPME. This result is similar to the report of Lemma Abara (2016) who indicated that the Lake Zeway fishermen distributed *O. niloticus* to hotels and supermarkets in Addis Ababa. According to the respondents the major fish products were transported to Sudan and Addis Ababa during fasting periods. This is due to the decrease in demand of fish from the customers in the surrounding markets during fasting seasons. On the other hand, there is high fish demand in Sudan and Addis Ababa during fasting periods.

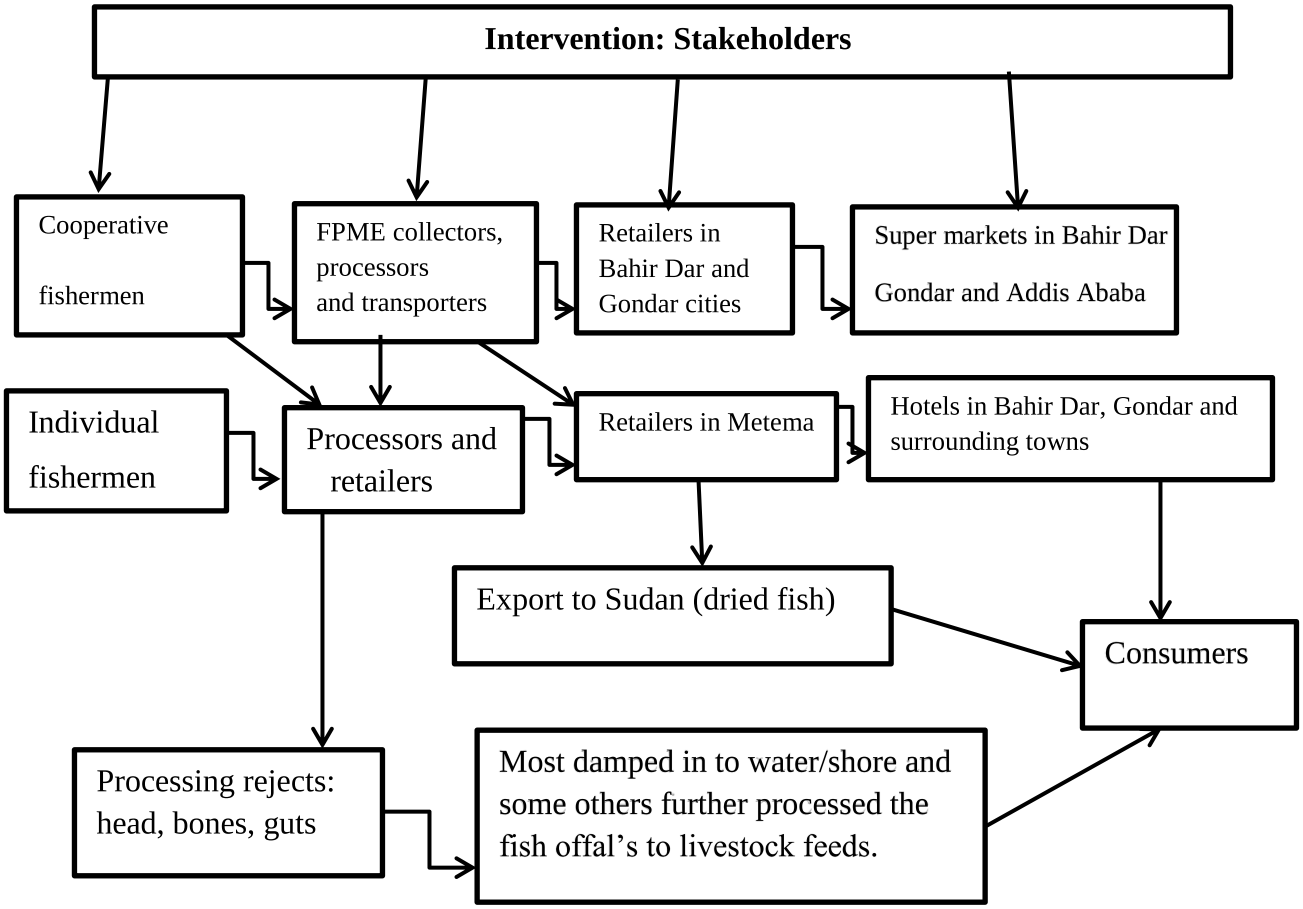

Figure 10. Value chains of the fishery products in the western part of Lake Tana (adapted from Brook Lemma, 2012).

4.6.9. Respondent's perception regarding Lake Tana fisheries status and management

All the respondents agreed that the Lake Tana fishery decreased compared to the last ten years and it is unable to satisfy the demand of customers in terms of fish quality and quantity (Table 21). Out of the total respondents, 65.5% had no awareness and training on wise use of fisheries resources of

Lake Tana in the last ten years. Among the respondents, 82 % of the fishermen used narrow filament (mesh size less than 8 cm) and only 18% used large size fishing gears to harvest different fish species. Similarly, 72% of the respondents had information about the breeding months, while 28% of the respondents had no information about it. Most of the fishermen (69%) do not participate to harvest fish throughout the year, 31% of the respondents harvest fish throughout the year.

Out of the total respondents, 69 % of them were willing to stop fishing during the breeding time while 31% of the respondents are not willing to stop fishing during the breeding season. The disagreement could be due to lack of other job opportunities by most of the fishers (Abduraman Kelil, 2002). From among the respondents (87.8%) of them had not information on Ethiopian fisheries development and utilization proclamation 315/ 2003 (1995E.C). Fishermen enterprises and fishermen associations had more information about this proclamation. The national proclamation was intended to serve as a framework for the regional states to develop their own proclamations, specific guidelines and management plans for the waters within their jurisdictions (Mulugeta Wakjira, 2016). Although, ANRS has its own fishery proclamation, it is not yet implemented as functional and useful (Abebe Getahun and Eshete Dejen, 2012 and Alamrew Eyayu, 2019).

Table 21. The perception of fishers' on the fishery trend and status in the western part of Lake Tana, Ethiopia.

Fishing activities	**Response rate (%N)**	
	Yes	**No**
Awareness or training on wise use of fisheries resources	34.5	65.5
Use narrow filament (mesh size less than 8 cm.) to harvest small sized fishes	18	82
Do you know the reproduction months of fishes?	28	72
Harvest fishes from this lake in all 12 months in a year?	31	69
Stop harvesting fish during the breeding season of fishes?	31	69
Do you know Ethiopia's fisheries development and utilization proclamation 315/ 2003 (1995 EC)?	12.2	87.8

The entire respondents agreed that the release of different chemicals from agricultural inputs and other sources into the lake had an impact on the fishery resources (Table 22). Similarly, the majority of the respondents, 69.5 % (137) indicated that the poor watershed management system was a factor to decreased fish production in the study area. According to the respondents, 59.5% (117) of them agreed that increasing number of fishermen is the main factor for reduction in size and number of fishes.

This is similar to the report of Abduraman Kelil (2002); Alebachew Tilahun *et al*. (2016); Erkie Asmare *et al*. (2016) and Mathewos Temesgen (2017) in which it was stated that an increasing number of fishermen often translates into increasing fishing pressure on the fishery resources.

Among the total respondents 73.6% (145) used illegal fishing gears and it is also the major factor to decreased fish size and number of species in the lake. According to personal observation, the monofilament gill net (mesh size < 8cm) was one of the major problems to decreased Lake Tana fisheries. Similarly, many researchers confirmed the reduction of mesh size in different parts of Ethiopia had negative implications on capture fisheries (Shewit Gebremedhin *et al*., 2013; Erkie Asmare *et al*., 2016 and Lemma Abera, 2016). Majority of the respondents 82.2 % (162) agreed that destruction of wetlands through agriculture, irrigation and overgrazing decreases fish production. This might be because some fish species breed on wetlands, which serves as the breeding and nursery site for different fish species. This has created considerable water level declines which damaged the breeding grounds of fish species that spawn in shallow parts of the lakes, such as *Oreochromis niloticus* (Tadlo Awoke and Mebratu Melaku, 2017). Out of the total respondents, 84.8% (167) of them perceived that one of the factors for the decrease in fish production in Lake Tana, is fishing during the breeding season. This is similar to the findings of Dereje Tewabe (2015) that confirmed that all fishers (both reed boat and motorized boat) fishing pressure mainly concentrate on breeding season and spawning ground of the species in Lake Tana. On the other hand, most of the respondents, 64% (126) held Tana Beles hydroelectric power to have had a negative impact on the fish production in the Lake Tana fishery. Some fishers also perceived the migratory *Labeobarbus* species declined as a result of this hydro power. Even though, there was filter in the inlet of Tana Beles hydroelectric power, the filters allow fish to enter into the turbines and caused mortality of fish and some pass through it and are found at the outlet (Dagnew Mequanent and Minwyelet Mingist, 2019).

Table 22.The perception of fishers' on possible factors that might have contributed to their perceived decrease in fisheries production in the western part of Lake Tana, Ethiopia.

Factors	Response rate (%)		
	Agree	Disagree	No opinion
The Poor watershed management system was followed	69.5 (137)	19.3 (38)	11.2 (22)
Increase number of fishermen	59.4 (117)	13.2 (26)	27.4 (54)
Fishing during breeding season	84.8 (167)	0	15.2 (30)
Use illegal fishing gears	73.6 (145)	0	26.4 (52)
Release of different chemicals from agricultural inputs and other sources into the lake	100 (197)	0	0
Destruction of wetlands through agriculture and overgrazing	82.2 (162)	0	17.8 (35)
The impact of Tana Beles hydroelectric power	64.0 (126)	0	36.0 (71)

4.6.10. Focus group discussion and key informant interviews

Both focus group discussants and key informants mainly discussed on the factors and management option of Lake Tana fishery (Appendix 9). Most of the members of group discussants indicated that the fish production trend of Lake Tana decreased in the past ten years in terms of fish size and fish species. The focus group discussants and key informants perceived information on the problems of fishery in the western part of Lake Tana include fishing during breeding season, increased number of illegal fishermen, lack of institutional integration and poor government attention, poor watershed management approach and use of illegal fishing gears (including poison plants, monofilaments, cast nets and small size gears). They also agreed that one of the major factors for the decrease in fish production in the western part of Lake Tana was due to overfishing at mouths of rivers and flooded areas during the breeding season (May up to August). They also believe that some fish species were lost before five years ago. For instance, *Labeobarbus beso* was the most preferred fish species and had more customer's demand in the western part of Lake Tana. But today, it was not found from the fishermen's catch. Most of the members indicated that the majority of fishermen did not consider the Lake Tana fishery as their own resource and did not care about its future fates. This might be due to most of the fishermen are organized and given fishing license without defined criteria. Even though there were a fishing permission criteria in each livestock and fishery development office of each district, it is not properly implemented on the ground. The majority of the key informant interviews agreed that most fishermen did not have information on Ethiopian proclamation and regulation on the development and utilization of fishery resources (315/2003). Both the focus group discussants and key informant interviews agreed that the proclamation on the development and utilization of fishery resources are not being implemented. The focus discussants and key informant interviews mentioned that the following fishery management measures on Lake Tana should be taken awareness creation and training for fishermen related to fishing activity and management system, limit the number of fishermen, closed season during fish breeding season, encourage to organize fishermen enterprises and fishermen associations, creating buffer zone and control number of fishing gears and mesh size. They also agreed that the government should support and provide credit service to purchase recommended fishing materials. Finally, they agreed that there must be institutional integration among different institutions with regard to the Lake Tana fishery.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The following conclusions are made from this study:

- A total of 6118 fish specimens belonging to 13 species were recorded. Cyprinidae was the most dominant family in terms of number of fish species. 11 species were recorded from family Cyprinidae and under the genus *Labeobarbus*. *Oreochromis niloticus* (46.24%) was the most abundant species in number and *C. gariepinus* (28.39%) was the second abundant species in the catch. *L. gorgorensis* (0.6%) was the least abundant species in the catch.
- Of the total specimens that were collected, 3362 (55%) were caught during the wet seasons and 2756 (45%) of fish specimens were caught during the dry season. In the wet season, a total number of 1432 specimens of *O. niloticus* were collected from all the sampling sites. In the dry season, a total number of 1397 (50.69 %) and 734 (26.63%) of *O. niloticus* and *C. gariepinus*, respectively were caught from all sampling sites.
- The total number of specimens of *O. niloticus* and *C. gariepinus* 2829 and 1737, respectively, were caught during the research period. A total number of 1552 *Labeobarbus* specimen was caught during the research period.
- A total weight of 2455 kg fish specimens were caught from the western part of Lake Tana during the study period.
- From the (% IRI), *O. niloticus* was the most important species during the dry season with value of 22.48 % and *C. gariepinus* was the most important species with the IRI value of 32.67% during the wet season. *L. crassibarbis* was the least important species with the IRI

value of 0.23% during dry season and *L. gorgorensis* was the least important species in wet season with the IRI value of 0.31%.

- The Shannon diversity index value of fishes in the western part of Lake Tana was H=1.6. The evenness value of fishes in the western part of Lake Tana was J=0.62. The highest Shannon diversity index value was recorded at Kunzila (H=1.74) and the lowest was recorded at Delgi (13 spp. H‟=1.55). The highest evenness value was recoded in the western par of Lake Tana at Kunzila (J=0.70) and the lowest value was recorded at Delgi J=0.60.
- The highest Shannon diversity index value (H=1.81) was recorded during the wet season at Kunzila and the lowest value was recorded (H´ = 1.3) during the dry season at Dengelber.
- The total fish catch composition in the study area were *O. niloticus* (54.3%), *C. gariepinus* (23.4%) and *Labeobarbus* spp. (22.3%). The fishing activities in study area were 87.8% fishing alone and 12.2% fishing in groups. The fishermen are categorized as 41.1% fulltime, 48.7 % part time and 10.2 % were seasonal fishermen in the western part of Lake Tana. Most of the fishermen used monofilament gillnets (64%) and only 36% used multifilament gillnets.
- Out of the total respondents 89.6 % owned traditional (reed boat) and only 10.4% used motorized boats.
- The average monthly income obtained from the fishery in the western part of Lake Tana was 2066.45 ETB/per individual fisherman.
- The major source of fish markets in the western part of Lake Tana were the surrounding towns.

5.2. Recommendations

Based on the above findings, the following recommendations were forwarded

- Awareness creation should be given for fishermen on the current status of Lake Tana fishery. More activities should be conducted to promote the conservation status of fishery resources for individual stakeholders.
- Illegal fishing activities such as small sized fishing gears, fishing at shore area and mouths of the river should be prohibited.
- Encourage and support the fishermen associations and fishermen enterprises to control illegal fishing activities.
- Limit the number of fishermen with regard to the economic status of the fishermen.

- Detailed study on the impact of Tana Beles hydroelectric power on Lake Tana fish production and fishery should be done.

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APPENDICES

Appendix 1: Major physico-chemical parameters and their level of significance

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Temperature	Between Groups	.673	2	.336	.439	.653
	Within Groups	11.493	15	.766		
	Total	12.166	17			
SP.Cond.(µs/cm 2)	Between Groups	185.743	2	92.872	1.179	.335
	Within Groups	1181.942	15	78.796		

	Total	1367.685	17			
TDS	Between Groups	444.333	2	222.167	.960	.405
	Within Groups	3472.167	15	231.478		
	Total	3916.500	17			
Salinity	Between Groups	.000	2	.000	.	.
	Within Groups	.000	15	.000		
	Total	.000	17			
Dissolved oxygen	Between Groups	.119	2	.059	1.793	.200
	Within Groups	.497	15	.033		
	Total	.616	17			
PH	Between Groups	.067	2	.034	.623	.550
	Within Groups	.811	15	.054		
	Total	.879	17			
Seechidepth	Between Groups	264.111	2	132.056	.243	.787
	Within Groups	8139.667	15	542.644		
	Total	**8403.778**	**17**			

Appendix 2: Some collected fish species during the study period

Labeobarbus brevicephalus *Clarias gariepinus*

Labeobarbus crassibarbis *Labeobarbus tsanensis*

Labeobarbus macrophtalmus *Labeobarbus gorgorensis*

Labeobarbus longissimus *Labeobarbus megastoma*

Labeobarbus platydorsis *Labeobarbus intermidues*

Labeobarbus truttiformis

Oreochromis niloticues

Labeobarbus nedigia

Appendix 3: Percentage of IRI of different fish species in each sampling site ((N=total number, W=Total weight (kg), F=Frequency of occurrence, IRI- Index of relative importance) of Delgi.

fish	**N**	**%N**	**W**	**%W**	**F**	**%F**	**IRI**	**%IRI**
Clarias gariepinus	690	29.68	181.5	28.76	6	100	2906.1	34.6

Labeobarbus brevicephalus	33	1.42	14	2.22	3	50	112.4	1.3
Labeobarbus crassibarbis	23	0.99	15.5	2.46	3	50	123.8	1.5
Labeobarbus gorgorensis	37	1.59	22	3.49	4	66.67	234.0	2.8
Labeobarbus intermedius	186	8.00	83.5	13.23	6	100	1331.3	15.8
Labeobarbus longissimus	37	1.59	21.5	3.41	4	66.67	228.7	2.7
Labeobarbus macrophthlmus	16	0.69	10.5	1.66	6	100	167.1	2.0
Labeobarbus megastoma	39	1.68	27	4.28	4	66.67	286.9	3.4
Labeobarbus nedgia	40	1.72	22.5	3.57	2	33.33	120.6	1.4
Labeobarbus platydorsus	74	3.18	47	7.45	3	50	375.6	4.5
Labeobarbus truttiformis	42	1.81	39.5	6.26	2	33.33	210.5	2.5
Labeobarbus tsanensis	20	0.86	10.5	1.66	4	66.67	111.8	1.3
Oreochromis niloticus	1088	46.80	136	21.55	6	100	2202.1	26.2
Total	**2325**		**631**				**8410.9**	

Appendix 4: Percentage of IRI of different fish species in each sampling site ((N=total number, W=Total weight (kg), F=Frequency of occurrence, IRI- Index of relative importance) of Dengelber

fish	**N**	**%N**	**W**	**%W**	**F**	**%F**	**IRI**	**%IRI**
Clarias gariepinus	610	27.14	324	32.43	6	100	3270.4	32.8

Labeobarbus brevicephalus	22	0.98	6.5	32.43	1	16.67	541.5	5.4
Labeobarbus crassibarbis	28	1.25	12	0.65	4	66.67	44.6	0.4
Labeobarbus intermedius	143	6.36	62	6.21	6	100	627.0	6.3
Labeobarbus longissimus	51	2.27	38.5	3.85	5	83.33	323.4	3.2
Labeobarbus macrophthlmus	25	1.11	11	1.10	6	100	111.2	1.1
Labeobarbus megastoma	29	1.29	21	2.10	6	100	211.5	2.1
Labeobarbus nedgia	35	1.56	22.5	2.25	5	83.33	189.2	1.9
Labeobarbus platydorsus	93	4.14	64.5	6.46	4	66.67	434.6	4.4
Labeobarbus truttiformis	46	4.14	34	3.40	3	50	174.3	1.7
Labeobarbus tsanensis	36	2.05	28.5	2.85	5	83.33	239.8	2.4
Oreochromis niloticus	1130	50.27	374.5	37.49	6	100	3799.0	38.1
Total	**2248**		**999**			**100**	**9966.6**	

Appendix 5: Percentage of IRI of different fish species in each sampling site ((N=total number, W=Total weight (kg), F=Frequency of occurrence, IRI- Index of relative importance) of Kunzila

fish	**N**	**%N**	**W**	**%W**	**F**	**%F**	**IRI**	**%IR**

								I
Clarias gariepinus	437	28.28	280.5	34	6	100	3428.3	37.1
Labeobarbus brevicephalus	26	1.68	17.5	2.1	4	66.67	141.7	1.5
Labeobarbus. crassibarbis	28	1.81	18.5	2.2	4	66.67	148.5	1.6
Labeobarbus intermedius	179	11.59	107.5	13.0	6	100	1311.6	14.2
Labeobarbus longissimus	41	2.65	24.5	3.0	5	83.33	252.6	2.7
Labeobarbus macrophtalmus	17	1.10	9.5	1.2	6	100	121.1	1.3
Labeobarbus megastoma	43	2.78	23	2.8	4	66.67	189.5	2.1
Labeobarbus nedgia	33	2.14	41	5.0	4	66.67	335.5	3.6
Labeobarbus platydorsus	67	4.34	51.5	6.2	4	66.67	417.7	4.5
Labeobarbus truttiformis	38	2.46	27.5	3.3	3	50	167.5	1.8
Labeobarbus tsanensis	25	1.62	17.5	2.1	5	83.33	176.6	1.9
Oreochromis niloticus	611	39.55	206.5	25.0	6	100	2539.6	27.5
Total	**1545**		**825**				**9230.0**	

Appendix 6: Shannon diversity index and evenness value in the western part of Lake Tana (Kunzila)

Species	**N**	**pi**	**lnpi**	**Pi*lnPi**	**H'**	**Evenness (J)**

Clarias gariepinus	437	0.28	-1.263	-0.357	1.74	0.70
Labeobarbus brevicephalus	26	0.02	-4.085	-0.069		
Labeobarbus crassibarbis	28	0.02	-4.011	-0.073		
Labeobarbus intermedius	179	0.12	-2.155	-0.250		
Labeobarbus longissimus	41	0.03	-3.629	-0.096		
Labeobarbus macrophthalmus	17	0.01	-4.510	-0.050		
Labeobarbus megastoma	43	0.03	-3.582	-0.100		
Labeobarbus nedgia	33	0.02	-3.846	-0.082		
Labeobarbus platydorsus	67	0.04	-3.138	-0.136		
Labeobarbus truttiformis	38	0.02	-3.705	-0.091		
Labeobarbus tsanensis	25	0.02	-4.124	-0.067		
Oreochromis niloticus	611	0.40	-0.928	-0.367		
Total	**1545**			**-1.74**		

Appendix 7: Shannon diversity index and evenness value in the western part of Lake Tana (Delgi)

Species	**N**	**pi**	**lnpi**	**Pi*lnPi**	**H'**	**Evenness (J)**
Clarias gariepinus	690	0.30	-1.21	-0.36	1.55	0.60
Labeobarbus brevicephalus	33	0.01	-4.25	-0.06		
Labeobarbus crassibarbis	23	0.01	-4.62	-0.05		
Labeobarbus gorgorensis	37	0.02	-4.14	-0.07		
Labeobarbus. intermedius	186	0.08	-2.53	-0.20		
Labeobarbus longissimus	37	0.02	-4.14	-0.07		
Labeobarbus macrophthalmus	16	0.01	-4.98	-0.03		
Labeobarbus megastoma	39	0.02	-4.09	-0.07		
Labeobarbus nedgia	40	0.02	-4.06	-0.07		
Labeobarbus platydorsus	74	0.03	-3.45	-0.11		
Labeobarbus truttiformis	42	0.02	-4.01	-0.07		
Labeobarbus tsanensis	20	0.01	-4.76	-0.04		
Oreochromis niloticus	1088	0.47	-0.76	-0.36		
Total	**2325**			**-1.55**		

Appendix 8: Shannon diversity index and evenness value in the western part of Lake Tana (Dengelber)

Species	**N**	**pi**	**lnpi**	**Pi*lnPi**	**H'**	**Evenness (J)**
Clarias gariepinus	610	0.27	-1.30	-0.35	1.58	0.64
Labeobarbus brevicephalus	22	0.01	-4.63	-0.05		
Labeobarbus crassibarbis	28	0.01	-4.39	-0.05		
Labeobarbus intermedius	143	0.06	-2.75	-0.18		
Labeobarbus longissimus	51	0.02	-3.79	-0.09		
Labeobarbus macrophthalmus	25	0.01	-4.50	-0.05		
Labeobarbus megastoma	29	0.01	-4.35	-0.06		
Labeobarbus nedgia	35	0.04	-3.19	-0.13		
Labeobarbus platydorsus	93	0.04	-3.19	-0.13		
Labeobarbus truttiformis	46	0.02	-3.89	-0.08		
Labeobarbus tsanensis	36	0.02	-4.13	-0.07		
Oreochromis niloticus	1130	0.50	-0.69	-0.35		
Total	**2248**			**-1.58**		

Appendix 9: Participants of group discussions and key informant interviews in the study area






Appendix 10: Questionnaires

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"Diversity, relative abundance and socio- economics of fish and fisheries in the western part of Lake Tana, Ethiopia

Part I: Interview for experts and respective local government bodies.

Dear respondents,

These interviews have been developed to collect data about the diversity, relative abundance, and socio- economics of fish and fisheries in the western part of Lake Tana and to suggest for appropriate management and sustainable utilization of fishery resources in Lake Tana. The researcher assures that the information gathered is intended for research purpose only.

Thank you in advance for the kind support.

The instruction for the enumrature: please mark 'X' from the box that provide alternatives and write your opinion on the space.

1. Field of the study____

2. Experience at work____

3. Name of the organization you work in ____________________________________

4. Sex: (1). Male ☐ (2). Female ☐

5. What are major responsibilities of your department in the field of fishery?

____

____

____

6. How many fishermen are there in your zone/woreda/kebele engaged in fishing activity?

(1). Male ☐ 2. Female ☐

7. Number of fishermen association _____________

(1). Male ☐ (2). Female ☐

8. Number of individual fishermen ________________

(1). Male ☐ (2). Female ☐

9. How do you justify the benefits of the fisheries activities to the local people (production, processing, marketing, gear making, etc)?

____

____

10. What are the contributions of fisheries selector to generate new source of employment for local people?

____

____

____

(1). Male ☐ (2). Female ☐

11. How many motorized boats are there in your woreda/kebele engaged in fishing activity? ____

12. How many fishing gears are set by each fisherman? ______________

13. Which gear is more dominant used by fishermen? ______

____

A. Multi-filament☐

B. Mono-filament☐

D. Beach seine net☐

E. Hooks and lines☐

14. Where is the source of fishing gears used by fishermen------------------------?

15. Do you have information about fulltime, per time and seasonal fishermen in your worda/kebele level?

If yes, how many fishermen are there?

A. Full -time fishermen ☐

B. Part time fishermen ☐

C. Seasonal fishermen☐

16. Do you think that the fishermen ever been given awareness or training on wise use of fisheries resources by a concerned Woreda or Zonal Bureau? __________ if yes, please give some details about the awareness creation/training. ____

____

17. Does your organization give technical support to the fishermen? ___________.If there is, please list type of support you are giving: -

____

____

____

19. Do your organizations give fishing license or permission? ___________

20. Are there defined criteria? ____

____

____

____

21. How many licensed fishermen are there in your zone/woreda/kebele? ________________

21.1. Unlicensed fishermen/illegal fishermen __________________

22. Are there any rules and regulation of fishery management on Lake Tana? ______

If yes, what are the rules and regulation that apply for fisheries management?

23. How do you control and manage the illegal fishing activity in Lake Tana? What are your management tools?

____

____

____

24. If not what are the major reasons? ____________________________________

____

25. Do you think that the resource management is effective and efficient? _________

If not, what do you suggest to alleviate the problem?

____

____

____

26. What are the regulatory framework that is available in the study area? How does the availability or unavailability of regulatory framework affect management of fishery in the area?

____

____

____

____

27. Are there any external factors that are out of the zone/Wereda's Livestock resource development and promotion office/agency mandate/authority that affect the regulation of Lake Tana fisheries production? If yes, what are these factors? Natural factors, institutional factors, policies, laws, political factors, others. (Specify)____

____

28. Who do you think should be involved in the proper and effective management of the fishes and fisheries to ensure sustainability (e.g. local government, livestock resource development and promotion agency, fishermen [both individual and cooperatives], entire local people, etc. in the western part of Lake Tana)?-

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Part II: Questionnaire for individual fishermen

Dear respondents,

These Questionnaires have been developed to collect data about the diversity, relative abundance and socio- economics of fish and fisheries in the western part of Lake Tana and to suggest for appropriate management and sustainable utilization of fishery resources in Lake Tana. The researcher assures that the information gathered is intended for research purpose only.

Thank you in advance for the kind support.

- **The instruction for the enumrature: please mark 'X' from the box that provide alternatives and write your opinion on the space.**

Region ----------------- Zone ------------------ Wereda ---------------- Town-------------- Kebele

1. Sex: Male ☐ Female ☐

2. Religion:- A. Christian-Orthodox ☐ B. Christian-Protestant ☐ D. Muslim ☐ E. Others ☐

3. Age- (in year): A. 14-20 ☐ B.21-30 ☐ C. 31-40 ☐ D. 41- 50 ☐ E. above 50 ☐

4. Education: A. No formal education ☐ B. Formal education 1-4 ☐ C. 5-8 ☐ D. 9-10 ☐ E. 11-12 ☐ D. Diploma ☐ E. First degree ☐

5. Marital status: A. single ☐ B. Married ☐ C. Divorced ☐ D. Widowed ☐

6. Family members (size) ____________

7. Fishing experience (in years): A. 1-5 ☐ B. 6-10 ☐ C.11- 15 ☐ D.16- 20 ☐ E. 21-30 ☐ F. Above 30☐

8. What was your reason to start fishing? ___________________________

____

9. How far is your home from Lake Lana (in km) --------------

10. How far do you travel to sell your fish? (In Km) ________

11. How many species of fishes do you fish from Lake Tana?

Their local names:

____

____

12. Which fish species is more available in the Lake as a whole?

____

13. Which species of fish is more available around the shore?

____

____

14. Which species are more preferred by your customer? ________, _____ its availability in the lake (better catch in kg): A. High☐ B. Low ☐ C. Very low ☐

15. Average amount of fish you harvest (Kg/ day) ______

16. Where do you sell your fish/ fish product? (You can choose more than one)

A. Direct to consumer ☐

B. To local outlets (cafeterias, hotels & restaurants) ☐

C. Fishermen association☐

D. Trader ☐

17. How do you sell your fish? (You can choose more than one)

A. The whole fish ☐

B. Processed: ☐ C. Filleted ☐ D. Cooked ☐

18. Market price of fish (Birr/Kg) __________

19. Your income per month-about _________birr.

A. 750-1000 ☐

B. 1100-1500 ☐

C. 1600-2000 ☐

D. Above 2000 ☐

20. Categorization of fishermen

A. Full time fishermen☐

B. Part time fishermen☐

C. Seasonal fishermen☐

21. If you are not full time fishermen, what are your other means of income? ____ , which one give you better income? ______________________________

22. Do you have other income in addition to fish collection?

If you say yes what are there?

____

____

____

23. Which type of fishing gear do you use?

A. Multi-filament☐

B. Mono-filament☐

C. Beach seine☐

D. Hooks and lines☐

24. How many gears you set in the lake per day?

25. Which type of boat do you use?

A. Motorized☐

B. Reed boat (Tankuwa)☐

26. How much is the price of a single gill net?

27. What is the size of gill nets you have been using in fishing?

A. Length (cm) ______B. Width (cm) _______C. stretched mesh size (cm) _______

28. Do you get any support from professionals on how to use the lake resources………?

29. In the last five years could you harvest sufficient amount of fish from this lake to support your family?

30. Yes or No, is the quantity and quality of fish you obtained satisfying your customers?

---

31. Do you use narrow filament (mesh size less than 8 cm.) to harvest even small sized fishes?

32. Do you know the reproduction months of fishes?

33. Do you harvest fishes from this lake in all 12 months in a year?

34. Are you volunteer to stop harvesting fish during breeding season of fishes?

35. Do you think that have you ever been given awareness or training on wise use of fisheries resources?

36. What do you think about fisheries production has changed since you have started fishing on the Lake Tana? A. Increased ☐ B. Decreased ☐ C. Same amount ☐ D. No opinion ☐

37. What are the reasons you think for fish decline in the lake?

38. Do you have awareness about the Ethiopia's fisheries development and utilization proclamation 315/ 2003 (1995 EC)? A. Yes ☐ B. No ☐

39. Do you believe that your overfishing or collecting immature fishes can aggravate the biodiversity destruction of the lake in the future?

A. Agree ☐ B. Disagree ☐ .

How? ____

____.

40. Are you volunteer to use recommended gill nets (With 8-10 cm mesh size) to avoid collecting small young fishes ___________

41. If your answer is NO for question 40, what are your reasons?

____

____

____

42. Do you believe other factors also contributed to decline of fishes in the lake? _________

If your answer is yes for question 42, please list out the possible factors you think:

____

____

____

43. What measures do you suggest to avoid fish destruction and to improve fish yield in Lake Tana? (You can choose more than one)

A. licensing and limiting the number of fishermen ☐

B. Closed season when fishes are reproduced ☐

C. Temporary closure of areas where fishing is prohibited ☐

D. Number of gears and boat restriction ☐

E. Others you think__________________________

____

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Part III: Questionnaire for fishermen association

Dear respondents,

These Questionnaires have been developed to collect data about the diversity, relative abundance and socio- economics of fish and fisheries in the western part of Lake Tana and to suggest for appropriate management and sustainable utilization of fishery resources in Lake Tana. The researcher assures that the information gathered is intended for research purpose only.

Thank you in advance for the kind support.

- **The instruction for the enumrature: please mark 'X' from the box that provide alternatives and write your opinion on the space.**

1. When was this fishermen association established?

2. Number of fishermen in your association ______ A. Male ☐ B. Female ☐

A. Urban ☐

B. Rural ☐

3. Amount of fishes captured by each member per day______________

4. Number of boats you used: A. Motorized ☐ B. Wooden ☐ C. Others ☐

5. Sizes of gear (fishnet filament size) you use in cm ____________

6. From where do you obtain the fishing gear you used? __________________

7. Method of preservation _________________________ Number of refrigerators ___________

8. Means of transportation ______________, ___________, ___________

9. Market destination towns ____________, _____________, __________, ___________

10. In which town are you selling more fishes? _____________ _____________

11. Market price of fish (Birr per Kg)? _________

12. Where do you sell your fish/ fish product? (You can choose more than one)

A. Direct to consumer ☐ B. Traders ☐ C. To local outlets (cafeterias, hotels & restaurants) ☐

13. Average amount of income you get individually per month? _________

14. What is your fishing category?

A. Full time fisher men ☐
B. Part time fishermen ☐
C. Seasonal fishermen ☐

15. Do you think that you are satisfying your customers in terms of quality and quantity of fishes from Lake Tana in last few years? A. Yes ☐ B. No ☐

16. If your answer is NO why? ____
____

17. Do you have awareness about the Ethiopia's fisheries development and utilization 315/2003 (1995 EC)?

A. Yes ☐ B. No ☐

18. Do you think that have you ever been given awareness or training on wise use of fisheries resource?

A. Yes ☐ B. No ☐

19. Are there any supports from government offices and professionals for your fishing activity?
A. Yes ☐ B. No ☐

If the answer is yes, please list down type of support you got.

______________________,_________________________, _________________,

____

20. What factors are contributing for fish decline in Lake Tana? (You can choose more than one).

A. Water hyacinth expansion ☐

B. Overfishing by illegal fishermen ☐

C. Irrigation ☐

D. Others___________

21. If there other factors, please list down the possible factors you think;

____

____

____

22. Do you believe that Government bureau is working effectively to alleviate the problem?

A. Agree ☐ B. Disagree ☐ C. No opinion ☐

23. Are there any Lake management experiences from responsible partners? Or measures taken by responsible offices to prevent fish destruction? ______

24. If your answer is yes for question No 23, what are they? _________________,

_____________________________, ________________________ __________,

_____________________, _____________________.

25. What are the important measures you suggest to avoid fish declines?

_________________________________,____________________________

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Part IV: Questions for group discussion

Dear respondents,

These Questionnaires have been developed to collect data about the diversity, relative abundance and socio- economics of fish and fisheries in the western part of Lake Tana and to suggest for appropriate management and sustainable utilization of fishery resources in Lake Tana. The researcher assures that the information gathered is intended for research purpose only.

Thank you in advance for the kind support.

- **The instruction for the enumrature: please mark 'X' from the box that provide alternatives and write your opinion on the space.**

1. What was the fishing activity before ten years in the western part of Lake Tana?

___

___

2. Which kinds of fishing gears were used by the fishermen?

___

___

3. Which fish species was more dominant?

___

___

4. What was the number of fishermen engaged in fishing in the western part of Lake Tana before ten years?

   A. Male ☐ B. Female ☐

5. What were the problems which faced the fishermen during fishing activities?

6. What is a current fishing activity particularly in the western part of Lake Tana?

7. How does the government body is managed the fish resources properly?

8. Do you expect that the Lake Tana fisheries are managed properly?

9. Do you expect that the fishermen satisfy the customers by providing sufficient amount of fish, if you say No what are the problems?

10. What do you think about the current fishermen to accept the fisheries proclamation and regulation?

11. What are the major problems that affect the fish production in the western part of Lake Tana?