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Assessment of artisanal fishery and indigenous knowledge on fisheries of Lake Zeway, Oromia Regional State, Ethiopia

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Thesis Submitted to the Department of Biology, School of Graduate Studies, College of Natural Sciences, Jimma University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Biology (Ecological and Systematic Zoology)

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Assessment of artisanal fishery and indigenous knowledge on fisheries of Lake Zeway, Oromia Regional State, Ethiopia

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Declaration

I, the undersigned, hereby declare that this thesis is my original work, it has not been presented fora degree in any other University and all sources of materials used for the study have been duly acknowledged.

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Signature Date

This is to certify that this thesis entitled “Assessment of artisanal fishery and indigenous knowledge on fisheries of Lake Zeway, Oromia Regional State, Ethiopia, submitted in partial fulfillment of the requirements for the award of Degree of Master of Science inEcological and Systematic Zoology to the Graduate Program of the College of Natural Sciences, JimmaUniversity by AkliluLegeseis an authentic work carried out by him under our guidance. The matter embodied in this work has not been submitted earlier for the award of any degree or diploma to the best of our knowledge and belief.

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Acronyms

EMC: Ethiopian Meat Corporation

EOC /DICAD: Ethiopian Orthodox Church / Development and Inter-Church Aid Department

FAO: Food and Agriculture Organization of the United Nations

FDRE: Federal Democratic Republic of Ethiopia.

FPMC/E: Fish Production and Marketing Corporation/ now Enterprise

IK: Indigenous Knowledge

Abstract

The present study was aimed to assess artisanal fishry and indigenous knowledge on fishing maintained by local people around Lake Zeway. To know fish status, fish samples were collected from fishermen catch during wet (April and July 2020) and dry seasons (October and November 2020) by the aid of fishermen using indigenous fishing methods and gill nets with (6, 8, and 10cm, stretched mesh size). Field observations and questionnaires were used to collect data from sample respondents on artisanal fisheryand indigenous knowledge. A total of 1360 fish specimens were recorded from the three families. The species were: Oreochromis niloticus and Coptodon zillii from the family Cichilidae (46.10%); Carassius carassius, Cyprinus carpio, Enteromiuspaludinosus, Labeobarbus intermedius and Labeobarbusa ethiopicus from the family Cyprinidae (47.80%); and only Clarias gariepinus from the family Clariidae (6.10%). During this study, Cyprinidae relatively dominated the fish composition of the lake. At the species level, Oreochromis niloticus was the dominant fish species from the Family Cichilidae as well as the whole species of the lake (38.16 %) followed by Cyprinus carpio with (24.63). The species diversity status for the lake was between 1.5 and 1.65 with relatively high species diversity observed in Bashra Chefa. The study also revealed that the fishers' indigenous knowledge related to fish and fisheries show clearly the value of this knowledge provides a necessary base for sustainable use of fish resources of the area. There are traditional fishing methods such as Hand kicking, pool-trapping, hand picking and others developed by the fishermen. The tools they used to catch fish were made manually from locally available materials such as Gubo tree, Balsa wood, cotton thread. From this point of view, indigenous knowledge was playing a vital role in the livelihood of the poor fishermen. Therefore, this knowledge should be upgraded and documented for further usage of the coming generations. To upgraded and document this knowledge, detailed studies and investigations are required.

Key words: Assessment, fishing crafts, fishing methods, gears, indigenous knowledge, Lake Zeway

1. Introduction

1.1 Background of the study

Fishes are the most diverse of all the vertebrate taxa. They constitute more than 27, 977 (> 50 %) of the 54, 711 extant vertebrate species (Nelson, 2006). Freshwater fishes comprise until now almost 13,000 species (and 2,513 genera) (including only freshwater and strictly peripheral species), or about 15,000 if all species occurring from fresh to brackish waters are included (Nelson, 2006). The precise number of extant fish species remains to be determined. About 28,900 species were listed in FishBase worldwide in 2005, but some experts feel that the final total may be considerably higher. As of 2015, the searchable catalog contains entries for about 58,300 fish species names, about 33,400 of which are currently accepted (valid), and for some 10,600 genera (5,100 valid) (Eschmeyer and Fong, 2015). In recent times, the number of fishes is increasing. According to FishBase, 34,300 species of fish had been described as of September 2020 (Froese and Pauly, 2020). But in most recent times, 35,797 species were listed in the Catalog of fishes (Fricke *et al*., 2021).

According to Leveque et al. (2008) South America is the leading continent in terms of freshwater fish by possessing 4,035 species belonging to 74 families. While Asia and Africa are the second and third next to South America with 3,553 and 2,945 species in 85 and 48 families, respectively. InEthiopia, several water bodies that contain a high diversity of aquatic fauna. The inland water body of the country is estimated to be 7,400 km^2 of lake area and about 7,000 km total length of rivers (Wood and Talling, 1988) with diversified fish species. There are several studies in Ethiopia on fish diversity. The first review on Ethiopian freshwater by ShibruTedla (1973) listed 93 fish species. Later on, reviews (Golubstov and Darkov, 2008) listed up to 153 valid indigenous fish species and subspecies in 25 families for the Ethiopian freshwater systems. In recent times, about 168 to 184 fish species including 53-54 country- wide endemics was described (Golubtsov and Darkov, 2008). The annotated checklist of the fishes of Ethiopia contains 200 species belonging to 75 genera, 31 families and 12 orders (RadeatHabteselassie, 2012). There are several important fish species in Lake Zeway and many studies were conducted on the lake to assess fish species diversity. For example, studies by Golubtsov et al. (2002) recorded seven indigenous fish species comprising *Enteromius paludinosus, Garra dembecha, Garra makiensis, Labeobarbus aethiopicus, Labeobarbus intermedius, Labeobarbus microterolepis* and *Oreochromis niloticus*. But the most recent works of Abera (2016) identified ten fish species (six indigenous and 4 introduced) with low species diversity for the lake (H′ value of 1.67).

To harvest these fishery resources, knowledge of fishing gear, crafts and fishing methods is very essential. Fishing nets and gears are referring to those devices having different shapes and sizes and are used in the aquatic bodies to capture different sizes of fish species (Shafiul *et al*., 2014). They can be made locally from available materials or processed in industries. They are used to collect or harvest fish and on the other hand; crafts are used to carry the fishermen and gears to fishing grounds. Various types of materials are used to make these fishing gears include netting, twine, plastics, clips, ropes, steel, wire ropes, combination wire ropes, purse rings, cotton, mixed fibers, floats and sinkers, bamboo, wood, etc. (Devi, 2014). Fishing techniques employed in a geographical area generally depend on various behavioral characteristics and the micro habitat type of the fish fauna available in that area. Seasonal changes, physiography of the water body, types of fish available, the efficiency of the gear, characteristics of the material used for the preparation of gear are the important factors that determine the selectivity of the gear used. A thorough understanding of fishing craft and gear is crucial for understanding the present exploitation mechanism of natural fishery reserves and conservation and also for making suitable improvements of valuable fish resources.

In fisheries management, IK can complement knowledge of modern science of resource management by providing long-term baselines for stock assessments, local knowledge of species' ecology and behavior, habitat conditions, fish utilization and customary management systems. Fishing technology on Lake Zeway is artisanal in nature and makes use of traditional rafts and wooden manual boats to harvest fishery resources. The present study was attempted to assess ecological, historical and cultural value of the traditional knowledge on fisheries of Lake Zeway.

1.2 Statement of the problem

Over the past few decades, fish resources decreased dramatically, and endemic species have faced continuous threats globally (Guo *et al*., 2018). It is a known fact that overfishing, water diversion, pollution, global climate change, land erosion and other anthropogenic activities are considered as the main threats to fish biodiversity (Arthington *et al*., 2016). Today the fish diversity and associated habitats management is a great challenge and the ability to evaluate the effects of habitat change and other impacts on the fish population required extensive surveying of the fish population before and after the change occur (Dudgeon *et al*., 2006).

Modern fishing devices like motorized fishing gears, nets of smaller mesh size, dynamite fishing is threats to increase pollution destroy the natural environment and affect fish

biodiversity. But the ancient tradition of fishing by using traditional devices and knowledge has become sustainable way of harvesting inland fishery resources without causing any damage to aquatic environment (Laxmi *et al*., 2013).Thus, these eco-friendly fishing techniques must be documented, preserved, scientifically upgraded and promoted for future use to conserve our fishery resources and this study help to preserve and document fishing activities of communities around Lake Zeway to provide their livelihoods. Therefore, the present study utilizes the case study approach to assess fish status and IK on fisheries of Lake Zeway.

1.3 Research Questions

The following questions were addressed through the study:

1. What is the status of fishes in LakeZeway?
2. What are the traditional fishing methods (including as traditional crafts and gears) and post-harvest activities (i.e., processing, storage and transportation) applied in the study area?
3. What is the traditional knowledge on species distribution, migration, behavior, etc. (Knowledge that members of the local community have of the biological and ecological attributes of fish species).

1.4 Objectives of the study

1.4.1 General objective

The general objective of this study was to assess artisanal fisheryand IK on fisheriesof Lake Ziway.

1.4.2 Specific objectives

- To assess fish species status of LakeZeway from fishermen catch
- To explore the traditional fishing methods and post-harvest activities (i.e., processing, storage and transportation) applied in the study area
- To explore traditional knowledge of members of the local community about the biological and ecological attributes of fishes.

1.5 Significance of the study

The information on fish status and relative abundance in the present study will help in the appraisal of the fish status of Lake Zeway from the past studies. The information on fisheries related indigenous knowledge would serve as a baseline for more comprehensive future

studies on the subject. The information also serves as an input for the policy makers to encourage and support indigenous knowledge for sustainable utilization of fisheries resources thereby improving the livelihood of the communities depending on the lake fishery. To this end, the data collected for this study would lay ground for further studies, documentation, preservation, revitalization and empowerment of the culture based on the preferences of the community.

2. Literature Review

2.1 Fish species diversity

Among the organisms, fishes are the best-known species of aquatic organisms and they are the only food source harvested from natural populations. Furthermore, fishes exist at or near the top of the food chain and can serve as an indicator of a balanced aquatic ecosystem (Gorman and Karr, 1978). Fish diversity comprises of species richness (number of species in a defined area), species abundance (relative number of species) and phylogenetic diversity (relationships between different groups of species) (Gorman and Karr, 1978).

Fishes constitute more than 27,000 of the known 54,000 species of living vertebrates and are divided taxonomically into three major groups: jawless fishes (agnathans), cartilaginous fishes (chondrichthyans), and bony fishes (osteichthyans) (Helfman *et al*., 2009; Nelson, 2006).

According to Leveque et al. (2008) South America is the leading continent in terms of freshwater fish by possessing 4,035 species belonging to 74 families. While Asia and Africa are the second and third next to South America with 3,553 and 2,945 species in 85 and 48 families, respectively.

In Ethiopia, according to Golubtsov and Darkov (2008), though not supplemented with the actual list, the ichthyofaunal diversity of the country has increased from 93 species (Shibru Tedla, 1973) to 184 (native) in 70 genera and 29 families, with 4–5 exotic species. But the works of Radeat Habtesilassie (2012) increased the number of species to 200 and above. It appears that a listing of about 191 valid indigenous species and 9 exotic species and sub-species represents what is so far known from Ethiopian waters. Of the 191 total species and sub-species, about 53 species and one sub-species are endemic to Ethiopia. Based on this study, the highest species diversity is recorded from Baro Okobo basin (119 species), followed by Omo Turkana (79 species), Abay (Blue Nile) (61 species), Tekeze and Awash rift valley system (36 species each) and Shebelle-Genale (33 species).

There are several important fish species in Lake Zeway and many studies were conducted on the lake to assess fish species diversity. For example, studies by Golubtsov et al. (2002) recorded seven indigenous fish species comprising *Enteromius paludinosus, Garra dembecha, Garra makiensis, Labeobarbus aethiopicus, Labeobarbus intermedius,* and *Labeobarbus microterolepis* and *Oreochromis niloticus*. But the most recent works of Abera

(2016) identified ten fish species (six indigenous and 4 introduced) with low species diversity for the lake (H′ value of 1.67). This shows the composition of the fishes has undergone some changes as compared to the last few decades.

Today the fish diversity and associated habitats management is a great challenge and the ability to evaluate the effects of habitat change and other impacts on the fish population required extensive surveying of the fish population before and after the change occur (Lester *et al.,* 1996; Dudgeon *et al.,* 2006). Fisheries cannot be managed effectively without integrating the stakeholder, involving fishers in the process and providing laws and regulations framework (Pomeroy, 1995). It is suggested that fisheries management should put the relationship of fisheries utilization to human welfare and the conservation for future usage in the first place. As in many parts of the world, in Ethiopia, the rate of degradation of the environment mainly by deforestation and overgrazing of grasslands by cattle, the population growth, the introduction of exotic species, agricultural development and industrialization contribute to the loss of species diversity of freshwater fishes (Abebe Getahun and Stiassny, 1998).

2.2 Indigenous Knowledge

2.2.1 What is Indigenous Knowledge (IK)

The first definition by Warren (1991) indicates the term indigenous knowledge (IK) is used synonymously with ‘traditional’ and ‘local’ knowledge to differentiate the knowledge developed by a given community from the international knowledge system sometimes also called the ‘western system’, generated through universities, government research centers and private industry. In a similar way, indigenous knowledge, also called traditional or local knowledge, results from the long-standing traditions and practices of certain regional, indigenous, or local communities; it encompasses the wisdom, knowledge, and teachings of these communities.

The definition of IK gives an emphasis on culture and society to address those concepts; Culture is a system of values and norms that are shared among a group of people and that when taken together constitute a design for living and they determine through religion, social structure, education, economic and political philosophy. In another dimension, Minang and McCall, 2006 stated that culture is the ways of thinking, the ways of acting, the material objects that together form a people’s way of life and variation in between different cultures but all have common elements which are Symbols, Language, Values, Beliefs, Norms, Ideal and Real Culture.

2.2.2 Characteristics of Indigenous Knowledge

Johnson, (1992); Minang and McCall, (2006), outlined some characteristics of indigenous knowledge. It is locally bound and 'owns' the knowledge, i.e. indigenous to a specific area that develops from the close relationship between local people and their land and natural resources, orally spread, informal experiments, intimate understanding of nature, accumulation of generation wise experiences, traits tested on "religious laboratory of survival", Internationale and not individualistic, empirical, functional (open-ended IK), culturally embedded (close-ended), technical with non-technicality, rational with non-rationality, repeating with time, asymmetrically distributed, shared by many Members of the community are expert repositories for different categories of data, according to their experience and social status, cost-free (or low cost) and attractive to outsiders in form of global public service. Such type of knowledge is not completely associated with aboriginal or indigenous commonalities. It is dynamic and adaptive, not static, changing as the society changes socially, economically, culturally, etc. but peoples in a wider periphery due to their association with traditional way of living. Whereas Weaknesses when conditions are new or changed; deficiencies in ways that information is stored and communicated; and little quantification of information for analysis in general IK has become an important and valuable input in the management of sustainable development programs (Ngulube, 2002).

2.2.3 Barriers of IK

There are basic barriers for IK which is in acquisition of IK;sharing of IK and preservation of IK as a result it was classified at the following categories: personal which are poor recognition of IK; poor knowledge sharing culture; lack of trust; and personal characteristics (that is, age, gender, status). Social barriers were related to the poor recognition of IK; a poor knowledge sharing culture; disappearance of traditional seeds and plant species; the difficulty of knowing the IK custodians; disappearance of IK holders; the dominant use of contemporary technologies; traditional structures, customs and taboos that inhibited sharing of IK; high illiteracy level of the early IK custodians; and disappearance of oral culture such as folklore and Further, the problems at the external environment level were related to the inadequate efforts by the government to recognize IK in its policies and plans, exclusion of IK in the formal education system and lack of professionals, such as extension agents to recognize and manage IK (Lwoga, 2011).

2.2.4 Roles of Indigenous Knowledge in fishery management

Globally, there is recognition of the valuable role that traditional knowledge held by indigenous communities can play in the contemporary management of natural resources.

Fisheries cannot be managed effectively without integrating the stakeholder, involving fishers in the process and providing laws and regulations framework (Pomeroy, 1995). It is suggested that fisheries management should put the relationship of fisheries utilization to human welfare and the conservation for future usage in the first place. Hence, an integrated approach which has emphasis to the role of people is needed.

Unfortunately, the social aspect dimension of natural resources is always the last priority. This is because the technical and scientific approaches are easy to measure and to calculate to find its objectivity. As such, the emotions, spiritual links and community values, aspects that have less validity and lack of certainty are left behind (Kay and Alder, 2005). In fishing, for example, globalization over natural resources leads to the full exploitation of fisheries resources driven by international markets. This condition is marked by a great effort to secure future access to fish stock by fishing gear enhancement or fleet modernization. Globalization in fisheries has also brought the issues of consumer health and conservation as well as animal ethic issue under international agreements and conventions on standards (Nelson 2006). These conditions of resource globalization cornered the fishers' livelihood in some ways. In one side, the resource exploitation caused stock depletion towards conflict of users as Hardin (1967) has already pointed out in Tragedy of common. Moreover, product standard compliance targeted environmental issues rather than fishers' interests. In the long term, the author argues that fisheries resources can become another paradox of plenty (en.wikipedia.org) as in the oil and mining business in developing countries. It will give a sort of benefit in the certain period before conflict of users and the resources disappearance brings people to live below the poverty line. Given that circumstances, understanding the interaction among the social, biological and economic fields is important. To end what Symes (1997) stated about multidisciplinary (biology, physics, and social) standoff in managing resources. It will create a strong pave way for fisheries governance and balancing the interest between the sustainability of fishery resources, ecosystem health and the socio-economic conditions that determine the quality of life of resources users (Hartoto *et al*., 2009). Therefore, the current fisheries management should enable stakeholders, particularly local people, to have an equal role in all coastal management processes.

2.2.5 Policy on Indigenous Knowledge

Policy is defined as whatever government decides to do or not to do regarding specific matters (Johnson, 1992). In the preparation and formulation of indigenous knowledge policies, it is essential for governments to engage actively with indigenous communities. Policy makers recognize the value of indigenous knowledge (World Bank, 2005).

A lot of government policies are not clear from a local community perspective. The key ingredient of any successful policy formulation and implementation involves the participation of a range of stakeholders. Stakeholders play an important role in motivating the policy, while motivation influences the capacity reasoning of policy. Monngakgotla (2009) points out that when policy framework ensures and recognizes indigenous knowledge as valuable knowledge, it enables communities to realize that they hold valuable knowledge. In this regard, countries should bring about public policy for the governance of indigenous knowledge. Indigenous knowledge in Ethiopia has not given attention specifically, but in FDRE constitution (1995) address in diversified ways article 5(1) recognition of language, article 39(2) right of people to preserve, develop culture, language and to preserve its history. Article 39(5) people is large measure of culture, intelligibility of language and contiguous territory and article 41(6) economic social and cultural rights state shall pursue policies.

2.3 Traditional/Artisanal fishing

Artisanal fishing, defined as a small-scale fishing, generally involves single individuals or small groups of fishers who use relatively simple equipment and techniques, and market their catches locally through intermediaries (Pauly, 2006). The small scale of this activity normally means that it has a reduced degree of impact on the environment (Orensanz *et al*., 2005). In coastal regions, the world over, subsistence fisheries primarily meet animal protein requirements for the inhabitants. People rely on fin and shellfish for much of their protein requirements. There is a wide diversity of habitats including coral reefs, estuaries, long river systems, and the open sea that contain a rich, under exploited fish resource. Lake fishing in inland regions, especially that relying on traditional methods, e.g., in Africa, southwest Asia, and China is also of considerable importance. In many areas of the world, the economics and politics associated with the introduction of new fishing technology (Development of Specialized Ships, Nets, and Equipment) has frequently led to a decline in fish stocks and the impoverishment of many traditional subsistence fishermen. For example, in the North Yemen fishery in the Red Sea, traditional gillnet and drift net fishermen suffered from the encroachment of company owned shrimp trawlers on their inshore grounds (Bene *et al*., 2007).

2.4 Fishing practices/systems in Ethiopia

In Ethiopia’s inland capture fishery, fishers make use of a variety of gear, including traditional traps and spear, gill nets, beach seine, hooks and logline. The crafts in use are generally motorized or unmotorized steel or wooden boats, reed or raft vessels. Most fishing

vessels are made of papyrus or scirpus and are unmotorized. In some of the Rift Valley lakes, particularly, Canoes have been gradually replaced by wooden punts with oars (4 m x 1.7 m x 0.55 m) while most fishers use one-man rafts (FAO, 2003). Though these vessels have very limited carrying capacity, they provide to the fisher the desired access to the entire surface area of the lake at an affordable cost. Also, outboard and inboard motorized vessels which enable fishers to operate throughout the water are available, most especially on Lake Tana, while wooden rowing boats are largely in use on Lake Awassa (FAO, 2003).

The predominant gear employed in the Ethiopian capture fishery is the gillnet, with the largest mesh sizes of up to 32 cm employed on Lakes Abaya and Chamo where bigger fish are caught (FAO, 2003). Beach seines are popular, particularly on Lake Langano, and occasionally on Lake Zeway during religious fasting. These beach seines measure between 150 m and 200 m long. In addition, traditional fishers harvest with on Lake Tana while on Lake Chamo, long lines and hook lines are employed to catch Nile perch (FAO, 2003). The Ethiopian Orthodox Church /Development and Inter-Church Aid Department (EOC /DICAD) project has provided some fishing gear repair and maintenance facilities which have organized a net manufacturing unit, with training for women, on Lake Tana (FAO, 2003).

2.5 Food fish utilization, processing and marketing in Ethiopia

Ethiopian consumers have preference for whole fresh fish. As a result, the bulk of the fish harvest from the lakes is sold fresh. However, frozen filets are increasingly being marketed in lakeside towns as well as in the capital city, Addis Ababa (FAO, 1995). Although most fish traders do not have access to basic cold chains with ice and insulated containers, a few basic fish handling and preservation institutions which are equipped with electricity and freshwater supplies are available in the Ethiopian fisheries. The main facilities are the chill store and ice at Zeway, freezing and cold store at Arba Minch, and a cold store at Bahir Dar area on Lake Tana (FAO, 2003). As a result of the general shortage of basic cold chains, fresh fish storage usually lasts only up to two days. Consequently, fish marketers concentrate their trade during religious fasting periods when there is more demand (Assefa, 2013).

Smoking is not a traditional method of fish utilization in Ethiopia, and drying is carried out only on some remote fishing locations (FAO, 2003). “Kuanta”, which is a dried fish product, is largely available around Arba Minch. The product is obtained by filleting the fish, cutting them into large strips and hanging them up on strings to dry for two to three days, after which they are packed in sacks for storage on the floor for up to a month without substantial quality deterioration. But while kuanta is not popular further north of the country, seasonal

processing takes place in the area of Lake Zeway during religious fasting periods (Assefa Mitike, 2014). Drying is increasingly becoming a method which is frequently used to preserve excess catches, with dried fish being more available in large consumption centers such as Addis Ababa, as well as being targeted at the expatriate market. And in addition to the traditional fish preservation methods, the Ethiopian Meat Concentrates, a subsidiary of the government-owned Ethiopian Meat Corporation (EMC) has carried out fish canning with a varied degree of success. Whereas, fresh fish handling hardly incurs post-harvest losses during religious fasting periods when demand is high and transactions rarely exceed 24 hours, at normal times, traders face major storage problems as a result of shortage of basic cold chains, thus resulting in significant losses. Because kuanta is generally prepared in poor hygienic conditions and insufficiently dried and stored on bare ground, it often incurs significant quality degradation. However, except for the Fish Production and Marketing Corporation now Enterprise (FPMC/E), post-harvest handling, processing, transportation and storage conditions by the fishers and middlemen were found to be very poor and unhygienic, which leads to high post-harvest loss (Tigabu*et al*., 2007). FPMC has been monopolizing the fish market for more than fifteen years, which allows the Corporation to determine the producers' price (at the landing sites) at a very low level (Breuil, 1995), while the price for consumers are high. For instance, FPMC was buying tilapia in Lakes Zeway, Awassa and Abaya-Chamo with only 0.5, 0.35 and 1.75 Birr/kg in 1990, whereas in the informal market prices were at 0.7, 1.20 and 3.20, respectively (Breuil, 1995). While the price of fish in the market has significantly increased during the past decade (e.g., tilapia fillet costs 50–75 Birr/kg depending on fillet size (indirectly size of the fish) in 2011), the producers (fishers) still get very low prices (FAO, 2003). Other forms of traditional processing and preservation techniques like smoking and salting are not commonly practiced by the fishers.

2.6 Indigenous fishing methods

The survey conducted by Sebastian et al. (2016) was aimed at assessing the indigenous fishing methods adopted by the fishermen in Lake Kolleru, India. Data regarding various indigenous fishing craft, gear and fishing methods was obtained from both primary sources (Direct observations from extensive field works, personal interviews) and secondary sources (Literature and Reports). The information was collected by participatory rapid appraisal covering fifteen fishermen villages in around the lake and field visits. The Study indicated that a diverse range of fishing gears and methods have been evolved over a long period of time by the fishermen of Lake Kolleru to capture a wide range of fish species and commercial of the lake. The indigenous fishing gears recorded during the study comprising ten varieties

of gears: Galamu, Dadikattu, Mavu, Gampagari, Sanchivala, Ettuduvala, Visuruvala, Odhe, Laguduvala and Moppavala falling under 6 categories and four fishing methods: Grouping (Hand picking), Doddi fishing (Dewatering), Kampagudu (Fish Aggregating Device (FAD)) and Gaya and three varieties of crafts such as Dhoni, Plank built boat and thermocol raft. It is evident that Dugout canoe, plank-built boats are the most extensively used craft and cast net traps are commonly used implements in fish capture during the study. The study result shows that, Kampagudu and Gaya are the unique and assured method of capturing fishes among all indigenous fishing devices in the lake. The study outlined no destructive methods are used in lake for fish capture.

Another study carried out by Sahadevan (2016) was aimed to collect indigenous knowledge possessed by the traditional fisher folk of the state of Kerala (South India) and to examine the traditional knowledge so collected in the light of the modern scientific knowledge. The information was collected by organizing three workshops and by holding focus group discussions (FGD) with the fishermen and people inhabiting coastal regions. In all these, traditional fishermen and local inhabitants living in the village who are acquainted with the lives of fishermen, officials of the State Department of Fisheries and scientists in the field were invited to participate. According to this study, some traditional knowledge possessed by the fishermen and coastal inhabitants include: one should not go to sea fishing when sea is covered with patches of red algae, presence of whales indicates abundance of fish, splashing of water on sea surface indicates presence of shoal of sardines, and presence of flock of sea birds is an indication of fish shoals. According to the same study, special type of local fishing methods documented were: *"Kolachal fishing"* (It involves using the spikes locally called *Kolachal*to attracting fishes, mainly cuttlefish), "*Baited floats to catch fish"* (the visceral mass of snail is used for bait), *"Branches of cashew nut tree as fish aggregating device"*, "*Scare lines from tender coconut leaves for catching fish"*, "*Fishing of snake heads (Channa spp.) with petromax and sickle"*, "*Use of charcoal from coconut shell to clear the well water",* (the charcoal adsorbs sediments and other substances that impart turbidity to well water and makes it clear), "*Use of tannin for preservation of fishing nets", "Coconut fronds in prawn filtration fields improve survival and growth of prawns" and "Singhi (Heteropneustes fossilis) for treating anemia in pregnant women and children"* (Regular consumption of kari, which is rich in high Iron content, helps get rid of anemia caused by the deficiency of iron).

A study conducted by Kalanda-Sabola et al. (2007) on use of IK for fishery management in chis island, Malawi. The paper presented results of a study, which examined local ecological knowledge and traditional management practices in lake resources management on Chisi Island. A combination of household questionnaires, semi structured interviews with key informants and focus group discussions were used to collect the required data for the study. The paper also includes review of other scientific studies done in the area to validate the survey results. The study found that Chisi inhabitants have developed and maintained some local ecological knowledge and practices that can have significant implications in scientific studies and on the management of lake resources on the Island. The practices included restricted cutting of Typha, fishing and access in sacred sites and conservation of Mabawe. These traditional practices encouraged regeneration and sustainable utilization of fish.

A brief account on traditional fishing methods and gears in Panay islands, Philippines was documented by Kawamura and Bagarinao (1980). They haverecorded various traditional fishingmethods andgearssuch ascollection byhands and feet, collection with small improvised tools, diving, wounding gears, stupefying devices, ichthyotoxic plants, lines, hand lines, pole and lines, troll line, jigs, traps, baskets, bag nets, scoop nets, dragged gear, seine net, surrounding nets, lift nets and gill nets.

A report on fish diversity and traditional fishing methods in Semi-arid irrigated system in the BajoVinalopo region, south eastern Spain was given by Belda et al. (2013). Fishing gears of the Meghna River Estuary of Chandpur, Region, Bangladesh have been documented by Siddiq et al. (2013). They have recorded 5 gill nets, 2 seine, 1 fixed purse, 1 cast net, 1 dip net, 1 lift net, 2 dragnet, 6 traps, 7 hook and lines and 3 wounding gears. Kingdom and Kwen (2009) have surveyed the fishing gears and methods in the Lower Taylor Creek Area, Bayelsa State, Nigeria. The results showed that the commonest gear used in the area include traps (60%), hook and line/long line (60%) and drift/gill nets (47.8%).

Two authors; Mberengwa and Bacha (2011), undertook a study in Ethiopia on the role of fishery in livelihood security of fishing communities around Lake Zeway. It was based on a sample of 125 households randomly selected from seven landing sites of the Lake. Focus group discussions, key informant interviews and personal observations were used to collect data. The study result shows that fishing technology on Lake Zeway is artisanal in nature and makes use of traditional rafts and wooden manual boats. Bamboo raft ('Bofofe or 'Yebela') is commonly used equipment for fishing by sample respondents (50.4%), followed by manual

wooden boats locally known as *Zeway boat* used by 48.4% of sample respondents. On the other hand, only one sample respondent did not have any type of boat.

3. Materials and Methods

3.1 Site selection

To assess the fish species diversity and indigenous knowledge related to fisheries around LakeZeway, four sites *viz*., Bekele Girisa, Abosa, Bashira Chefa and Bochesa were selected purposively based on geographical proximity and/or suitable landing sites. These sites were also selected because according to Mberengwa and Bacha, (2011), in these villages, majority of the tribal fishermen reside taking up fisheries on subsistence basis and use traditional knowledge and local tools for fishing accessories and rich in fish resources. Global Positioning System (GPS) coordinates were taken to demarcate the locations of the sampling sites. Bekele Girisa and Abosawere known by their vegetation cover, but in the later, the lake shore fishing was practiced by the fishermen. Bashira Chefa is a place with deep part of the lake (2.5- 4.5m) (Abera, 2016) and Bochesais known by prevalent anthropogenic activities such as irrigation and farming including Share Ethiopia Flower Farm.

3.2 Description of the study area

The present study was conducted at four fishing villages in Eastern Shewa and Arsi Zones, Oromia Regional State, *viz*. Bekele Girisa, Abosa, Bochesa and Bashira Chefa. The first three villages are located in Eastern Shewa Zone, while the last village, Bashira Chefa is an island which is found in Zeway Dugdadistirict (Wereda) of Arsi Zone (fig.1**)**.The village Bekele Girisais found in Dugda District near Meki Town, while Abosa and Bochesawere found in Adami Tullu Jido Kombolcha District.Zeway Town as a center of study site is located 163 km south of Addis Ababa and it lies on the lake's western shore serving as a market channel for all villages except Bekele Girisa. Some Geographic information of the study areas was also provided in table (1) below.

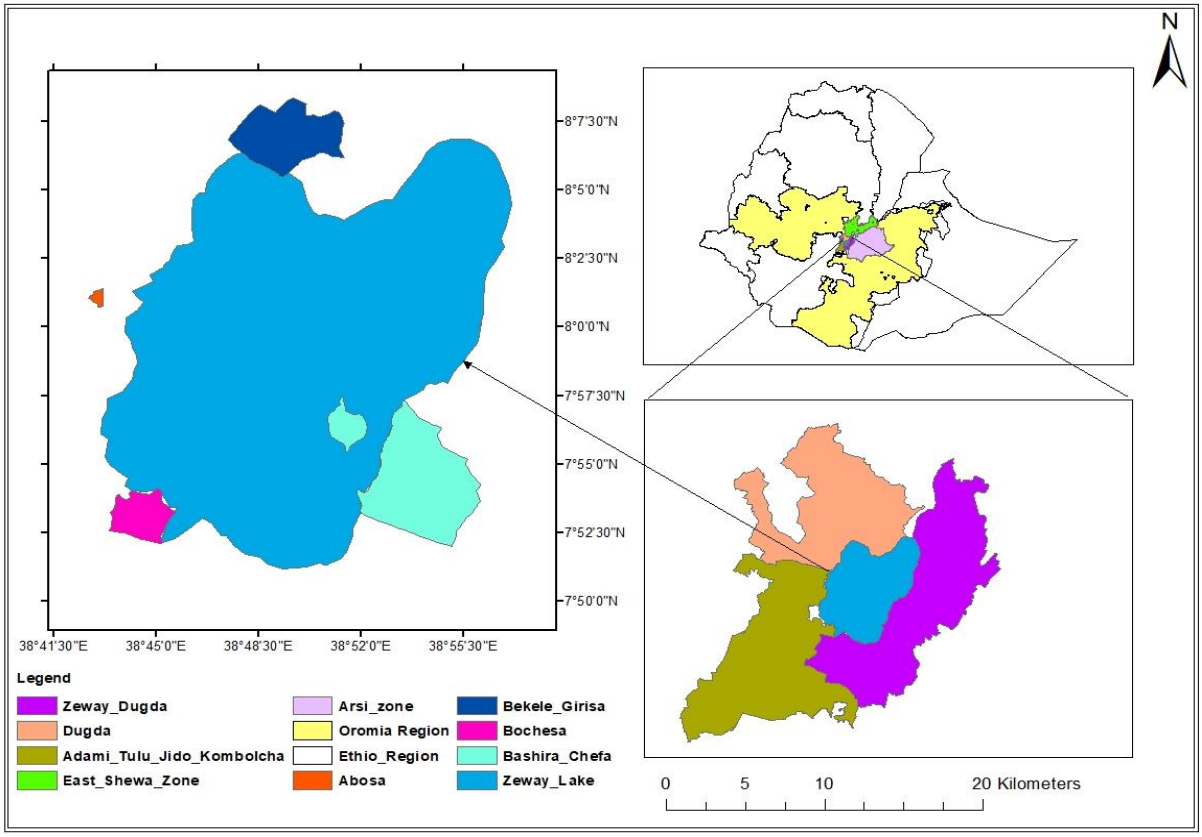


Fig.1: Map of the study area

Table 1: Some Geographic information of the study areas

Study sites	Altitude (m)	Latitude	Longitude	Relative location	Designation
Bekele Girisa	1642	$8^0$06.892'N	$38^0$48.348'E	A village to the North-West of Lake Zeway between Meki and Abosa	BG
Abosa	1643	$8^0$03.659'N	$38^0$43.459'E	A village 20 km North to Zeway town	Ab
Bashira Chefa	1620	$7^0$56.406'N	$38^0$41.509'E	An island to the East of Lake Zeway	BCh
Bochesa	1640	$7^0$53.508'N	$38^0$44.470'E	A village to the South-West of Lake Zeway	Bc

3.3 Sample size and sampling techniques for IK on fishing activities

The subjects of the study were fisher folks who were selected from each study site. The sample size was determined according to Yamane (1967) as follows by assuming a confidence level of 95% and a precision level of 5% as expressed below:

$n = N/ 1 + N (e)^2$

Where, n = sample size, N = total population, e = the error term

Table 2: Total population size and number of fishermen in the study areas

Study sites	Total population Fishermen					
	M	F	T	M	F	T
Bekele Girisa	2699	2581	5280	88	-	**88**
Abosa	2484	2009	4493	74	-	**74**
BashiraChefa	397	364	761	113	-	**113**
Bochesa	2146	2230	4376	126	-	**126**
Total	7726	7184	14910	401		**401**

(Source: Administrative offices of each villages, 2020)

Accordingly, total fishermen (N) of the whole villages were 401 (Table 2 above) and the sample size (n) for the study was 200 by applying the above formula. To show proportionality of sample size taken from each village, Bowley (1926) formula was used as follows:

$Ni = n\frac{Ni}{N} = Ki = \frac{Ni(n)}{N}$, i= 1, 2, 3.....Ki = village 1, 2, 3.....

Where, n represents sample size, Ni represents the population size of the i^{th} strata and N represents the population size. By applying this formula, the representative samples taken from Bekele Girisa, Abosa, Bashira Chefa and Bochesa were 44, 37, 56 and 63 respectively. Finally, these samples were taken purposively based on their fishing experience and by convenience sampling methods.

3.4 Data Collection tools

3.4.1 Fish sample collection and Identification

Fish specimens for species identification were sampled exhaustively from the fishermen catch. Fish samples were collected with the aid of fishermen using indigenous fishing methods and by using different types of nets namely gill nets with (6, 8, and 10cm, stretched mesh size) and hand lines and long lines. The specimens were collected during two seasons: the wet seasons (April and July 2020) and the dry seasons (October and November 2020). The local markets located on the banks of the lake were also visited to monitor and look for the presence of any species which were not available during fishing. Immediately photographs were taken before preservation since formalin decolorizes the fish color on long preservation. The specimens were preserved in 10% formalin and brought to Jimma University Aquaculture and Fisheries Laboratory for verification and storage. They were fixed in formalin solution based on their size in separate jars. Smaller ones were placed directly while the larger ones were preserved after giving an incision on the abdomen before they were fixed in the formalin solution (Fig.2). The specimens were identified to species level using relevant taxonomic keys Shibru Tedla, (1973); Golubtsov et al. (1995); Witte and Wim, (1995); Stiassny and Getahun, (2007); Radeat Habteselassie, (2012) and figures from FishBase. Finally, the specimens were labeled with scientific name, collector name, and place of collection and date of collection on each jar. Primary data on IK related to fisheries were generated by using questionnaires and direct observation (field visit). The instruments (questionnaires) were prepared in English language and translated into the Amharic language (Appendix 1) for the ease of data collection from the sample respondents.

Fig. 2: Laboratory identification and sample preparation of the fish specimens

3.4.2 Questionnaire

Data on IK were collected in the study area from April to October 2020 through semi-structured questionnaire (Appendix 2). The questionnaire type for the study was a researcher administered in the form of an interview. Before conducting the survey, a total of four enumerators (one for each village) who speak the local languages, Afan Oromo and Zay were recruited. The enumerators were also trained by the investigator before launching the survey to make them understand the purpose of the survey and to familiarize them with the questionnaire. Questionnaires were designed to request the quantitative and qualitative data on fishing methods, biological attributes of fishes and post-harvest activities. Content validity of the questionnaire was carried out by pilot test that was conducted on each site before the actual survey to reduce the difficulties of ambiguity and reduce the effect of bias conclusion and interpretation happening in the methods. In all of the above processes, participants were made to sit two meteres apart from each other (see fig. 3 below) due to the pandemic (Covid-19).

Fig 3: Respondents working on questionnaires at different study areas

3.4.3 Observation

Observation of the working environment was made by using an observation guide (Appendix 3). It was carried by watching and recording the traditional fishing gears and crafts that are used by the fisher folks, ways of processing and preservation of fish food, utilization, and other related events that take place in the fishing sites. Thus, during days of field work a researcher accompanied fishermen in their jobs and participates in the preparation of materials, catching, processing of fish and in a range of dining and recreational activities and social relationships that are related to these tasks.

3.5 Data analysis techniques

Fish species diversity status in the lake was computed using Shannon and Wiener Diversity Index (H'), (Shannon and Weiner, 1963), as follows:

$$H' = -\sum_{i=1}^{s} \left(\frac{ni}{N}\right) \times ln\left(\frac{ni}{N}\right)$$

Where, ∑ = sum from species 1 to species S

ni = number of individuals of species "i"

N = total number of individuals of all species

S = total number of species

H' = the Shannon- Weiner Index of Diversity

Species composition and abundance of fishes was analyzed by percentages and presented in tables and charts. All qualitative data obtained from primary data sources such as personal observation and questionnaires were analyzed and thematically presented in a narrative way. Quantitative data from questionnaires was analyzed using descriptive statistics i.e., Statistical Package of Social Science (SPSS, 2002). Descriptive statistics were used to create frequency tables and percentages showing the proportions of respondents who have knowledge of lake resources, their habits and particular traditional fishing methods.

3.6 Ethical considerations

The researcher considered the moral-ethical principles of the society under the investigation. Before gathering information, the researcher openly told the objectives of the study. During the study, the researcher was conscious in order not to be fully immersed intheactivity of the society, but rather perform the existing facts from the people and observe every activity around the station keep the confidentiality of informants by substituting their real name by

false name when they do not tell. Finally, the researcher respected the culture, beliefs, values, and practices of the people under investigation.

4. Results

4.1 Fish species Descriptions, Abundance and Diversity status from fishermrn catch

A total of eight species of fishes in the Families Cichilidae, Cyprinidae and Clariidae were identified from the different landing sites of the lake (Table3). An artificial identification key for these species was also provided in Appendix 4. The species were *Oreochromis niloticus* and *Coptodon zillii* from the Family Cichilidae; *Enteromius paludinosus, Carrasius carassius, Cyprinus carpio, Labeobarbus intermedius* and *Labeobarbus aethiopicus* from the Family Cyprinidae and only *Clarias gariepinus* from the Family Clariidae.

Table 3: Fish species identified from study sites of Lake Zeway (present (+), absent (-))

Family	Species	Sampling sites			
		BG	Ab	BChBc	
Cichilidae					
	Oreochromis niloticus	+	+	+	+
	Coptodonzillii	+	+	+	+
Cyprinidae					
	Carassius carassius	+	+	+	+
	Cyprinus carpio	+	+	+	+
	Enteromiuspaludinosus	+	+	+	+
	Labeobarbus intermedius	-	-	+	+
	Labeobarbusaethiopicus	-	-	+	-
Clariidae					
	Clariasgariepinus	+	+	+	+

4.1.1 Fish species descriptions

4.1.1.1. Family Cichlidae

Oreochromis niloticus (Linnaeus, 1757) (Plate 1):

Description: Dorsal spines (total) 15-18; dorsal softrays (total) 11-13; anal spines 3, anal soft rays 9-11. Head naked; Snout rounded. Protuberance is absent on the dorsal surface of snout. The mouth part is moderately large and terminal. Outer jaw contains several bicuspid teeth in 4 series rows. Eyes are visible from the dorsal only (supero-lateral). Body some-what compressed laterally, yellowish brown or greenish grey to dark olive above, whitish below. Scales are cycloid. Lateral line interrupted.

Diagnosis: A large deep-bodied tilapia, with a relatively small head. Most distinguishing characteristic is the presence of regular vertical stripes throughout depth of caudal fin at all life stages. Males are bluish pink, sometimes with a dark throat, belly, anal and pelvic fins; females are usually brownish, silvery/white beneath. Gill rakers short with 18 to 28 on the lower part of the anterior arc.

Distribution: The species was widely distributed in all sampling sites.

Plate 1: Side view of *Oreochromis niloticus*

***Coptodon zillii* (Gervais, 1848) (Plate 2):**

Description: Dorsal fin with XIV-XVI 10-13 rays; anal fin with III 7-10 rays; body usually with 6 to 8 more or less distinct cross bars. Outer jaw teeth bicuspid and non-spatulate, inner jaw teeth and posterior pharyngeal teeth tricuspid; micro-gillrakers present.

Diagnosis: A large, deep-bodied species with a narrow head and small strong jaws; lower pharyngeal bone about as long as broad, and with anterior lamella shorter than toothed area; gillrakers short, 8-11 on the lower part of anterior arch; median pharyngeal teeth not broadened. Body, brownish-olivaceous with an iridescent blue sheen, lips bright green, chest pinkish to red. Have a less-steep head profile and more prominent vertical bars. Scales on the flanks are wider than body scales.

Distribution: Distributed in the whole sampling sites of the lake.

Plate 2: Lateral and front view of *Coptodon zillii* (Red-belly tilapia)

4.1.1.2 Family Cypridae

***Carassius carassius* (Linnaeus, 1758) (Plate 3):**

Description: No barbels present; caudal fin bluntly lobed. Snout short and well rounded; eyes are very close to mouth. Juveniles have a black spot at the base of the tail, which disappear with age. Young fish are golden-bronze to silvery but darken with maturity, until they gain a dark green back, deep bronze upper flanks.

Diagnosis: Dorsal spines (total) 3 - 4; dorsal soft rays (total) 13 - 22; anal spines 2 - 3; anal soft rays 5-7; Caudal fin with 18-20 rays. There are 31–36 cycloid scales along the lateral line. The most distinguishing characteristic is a convexly rounded fin.

Distribution: The fish was found in all the sampling sites.

Plate 3: Front view of *Carassius carassius*

***Cyprinus carpio* (Linnaeus, 1758) (Plate 4):**

Description: Body elongated and somewhat compressed. Body length about four times body height. The mouth is terminal on the adult and sub-terminal on the young. The lips are thick and two pairs of barbels at angle of mouth, shorter ones on the upper lip. In Lake Zeway, there are sub-species either with a normal scale similar to other cyprinids or with large and thick scales (Abera, 2016). The sub-species have very variable in form, squamation, development of fins and color.

Diagnosis: The spines on both dorsal and anal fins are strongly serrated. Dorsal fin XVII to XXIII 3 to 4 rays; anal fin V to VI 2 to 3rays; Dorsal fins outline concave anteriorly. Lateral line with 32 to 38 scales. Two pair of barbels, body grey to bronze.

Distribution: The fish was distributed in all the sampling sites

Plate 4: Lateral view of *Cyprinus carpio*

***Enteromius paludinosus* (Peters, 1852) (Plate 5):**

Description: Dorsal soft rays (total): 8; anal soft rays: 6 - 7; barbels not well developed, anterior barbel very short, just reaching the posterior side of the maxilla, posterior barbel just reaching the middle of the eye.

Diagnosis: Last simple (unbranched) ray of dorsal fin is an enlarged, bony spine and is serrated behind; dorsal side brown-silver colored, ventral side silver, with a darker band on the flanks; fins not colored. Streaks are radially arranged on exposed edges of the scales. **Distribution**: The species was widely distributed in the whole sampling sites of the lake.

(a) (b)

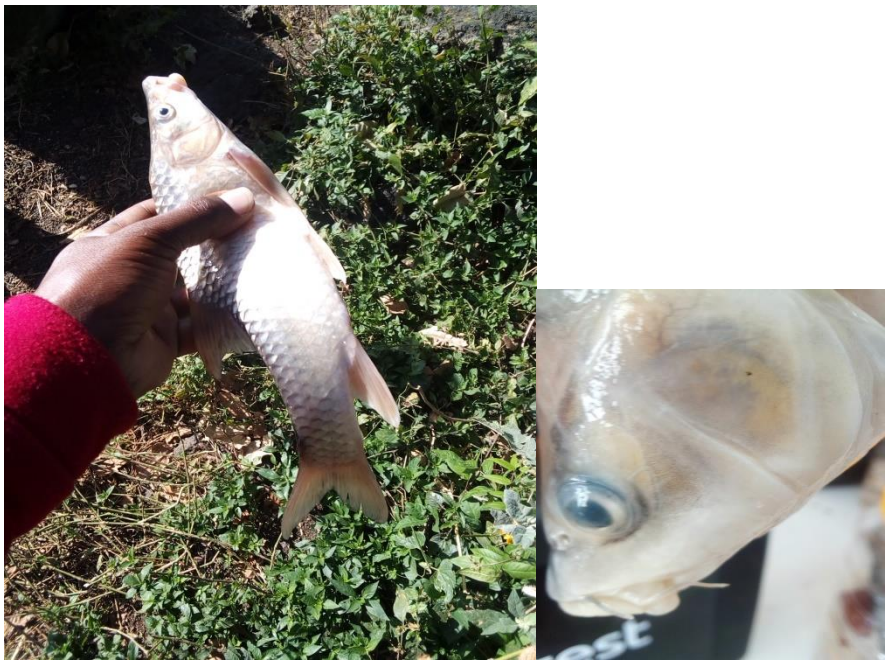
Plate 5: (a) Mouth parts and (b) lateral view of *Enteromius paludinosus* **(**Straight fined barbus)

***Labeobarbus intermedius* (Ruppell, 1835) (Plate 6):**

Description: Mouth terminal and protractile, its width 4 to 5 times in length of a head. Dorsal fin originates immediately above the pelvic fin. Dorsal and anal fin short the former with a sharp spine and the latter base shorter. Moderately developed dorsal spines are present. No adipose fin. Fresh specimens show extremely variable color but the most common color is light yellow.Body covered with cycloid scales.

Diagnosis: Eyes small, about 3 ½ to 6 times in length of head; Well-developed 2 pair's barbels on both sides of upper jaw only; 30-36 scales in the lateral line. Body depth is shallow and 19 to 32% of the standard length.

Distribution: The species was collected fromBashiraChefa and Bochesa sites of the lake.



(a) (b)

Plate 6: (a) Lateral view of *Labeobarbus intermedius,* (b) mouth parts

***Labeobarbusaethiopicus* (Zolezzi, 1939) (Plate 7)**:

Description: The last unbranched ray in the dorsal fin is ossified as a smooth spine, and two pairs of barbells are present.

Diagnosis: Easily distinguished by the large number of lateral line scales (46-52 in lateral line). There is no any species of barbswith this number of lateral line scales (Golubtsov *et al.*, 2002). Others have between 20-44lateral line scales. Dorsal fin with 3 to 4 unbranched rays and 6 to 8 branched rays; anal fin with 3 to 4 unbranched and 5 branched rays; pectoral fin with two unbranched and 14 to 15 branched rays.

Distribution: The species was collected only fromBashiraChefa site of the lake

(a) (b)

Plate 7 :(a) Lateral view of *Labeobarbus aethiopicus*(b) its mouth parts

4.1.1.3 Family Clariidae

***Clariasgariepinus* (Burchell, 1822) (Plate 8):**

Description: Eyes are relatively small, about 6.9% of head length, and are laterally placed. The head is large, depressed, and heavily boned. The mouth is quite large and sub-terminal in position. Four pairs (nasal, maxillary, outer mandibular and inner mandibular) of barbells are found around the mouth. There are two nostrils very close to the origin of nasal barbells. The species have small pointed teeth in large bands on the upper and lower jaws. Long dorsal and anal finswithout dorsal fin spine, anterior edge of pectoral spine serrated. Pectoral fins are very strong with spines that are serrated on the outer side. No adipose fin.

Diagnosis: High number of gills rakers, varying from 24 to 110 on the first branchial arch (more than 50 gill rakers in fish greater than 13 cm SL). Dorsal fin with 61 to 80 soft rays; 45 to 65 soft rays in anal fin; nasal barbels from 1/5 to ½ times as long as the head in fishes longer than 12 cm, and from half to 80% of the head length in smaller individuals. The presence of a pointed cleithrum is also a typical for *C. gariepinus*.

Distribution: The species is distributed in all the study sites of the lake.

Plate 8: Dorsal view of *Clarias gariepinus*

4.1.2Abundance of fishe species in fishermen's catch

A total of 1360 fish specimens were recorded from the three families during the study period, (Table4). The species were: *O. niloticus* and *C. zillii* from the family Cichilidae (**46.10**%); *C. carassius, C. carpio, E. paludinosus, L. intermedius* and *L. ethiopicus* from the family Cyprinidae (**47.80**%); and only *C. gariepinus* from the family Clariidae which accounts **6.10**% (Fig.4below). During this study, Cyprinidae relatively dominated the fish composition of the lake as had previously been observed in the study area (Abera, 2016).

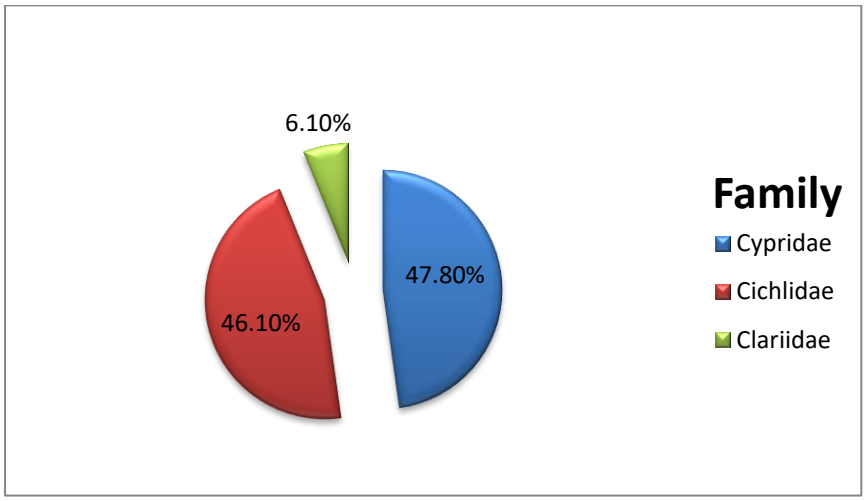


Fig.4: Composition of fish at family level in the lake

At species level, *O. niloticus* was the dominant fish species from the Family Cichilidae as well as the whole species from the lake and it accounts to 38.16 % of the total catch. *Cyprinus carpio* was the second dominant species which accounts to 24.63 %. *Carassius carassius* was the third dominant species with 14.48 %. *Coptodon zllii* and *Enteromius paludinosus* become 4th and 5th with 7.94 and 7.13% respectively and followed by *C. gariepinus* which is 6.10%. The remaining two species were less than 1% each (Fig.5below).

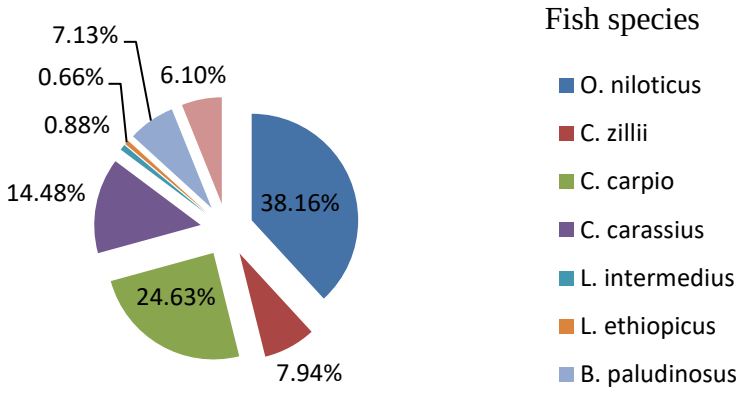


Fig.5: Fish species composition by number (%)

Table 4: Relative abundance of fish species caught from different study sites of Lake Zeway

Family	Fish species	Sampling sites									
		BG		Ab		BCh		Bc		Total	
		N	%	N	%	N	%	N	%	N	%
Cichlidae		178	13.08	165	12.13	126	9.26	158	11.61	627	46.10
	O. niloticus	146	10.73	125	9.12	103	8.25	145	10.58	519	38.16
	C. zillii	32	2.35	40	2.91	23	1.68	13	0.95	108	7.94
Cyprinidae		151	11.02	156	11.38	185	13.50	158	11.53	650	47.79
	C. Carassius	53	3.86	51	3.72	43	3.13	50	3.65	197	14.48
	C. carpio	73	5.32	80	5.83	102	7.44	80	5.83	335	24.63
	E. paludinosus	25	*1.82*	25	*1.82*	*20*	*1.46*	*27*	*1.97*	*97*	*7.13*
	L. intermedius	-	-	-	-	*11*	*0.80*	*1*	*0.07*	*12*	*0.88*
	L. aethiopicus	-	-	-	-	*9*	*0.65*	-	-	*9*	*0.66*
Clariidae		18	1.31	29	2.11	14	1.02	22	1.60	83	6.10
	C. gariepinus	18	1.31	29	2.11	14	1.02	22	1.60	83	6.10
Grand Total		**347**	**25.51**	**350**	**25.73**	**325**	**23.90**	**338**	**24.85**	**1360**	**100**

Source: field survey (November 2020- April 2021)

4.1.2.1Abundance of fishes during wet and dry seasons

Of the total specimens that were collected, 701 (51.54 %) were caught during the wet season (April and July) and the remaining 659 (48.46 %) specimens were caught during the dry season (October and November) (Table5; appendix 5). This indicates that relatively high numbers of fishes were recorded during wet season. Except for *O. niloticus* and *L. intermedius*, which areabundant in wet season than dry, all the rest of fishes were abundantin dry season than the wet season (Table5, appendix 5).

Table 5Relative abundance of fishesduring wet and dry seasons in the lake

Fishing sites	BG		Ab		BCh		Bc		Total	
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
O. niloticus	105	41	97	28	69	34	42	103	313	206
C. zillii	11	21	16	24	12	11	8	5	47	61
C. Carassius	30	21	25	28	22	21	16	34	97	104
C. carpio	44	29	30	50	45	57	48	32	167	168
E. paludinosus	10	15	11	14	12	8	12	15	45	52
L. intermedius	-	-	-	-	6	5	1	-	7	5
L. ethiopicus	-	-	-	-	4	5	-	-	4	5
C. gariepinus	10	8	5	24	5	9	5	17	25	58
Total	210	135	184	168	175	150	132	206	**701**	**659**

4.1.3 Diversity index

Three families and 8 species were recorded in the total of 1360 fish specimen collected during this study period (Table 4). The Shannon-Wiener diversity index was 1.5 for both Bekele Girisa and Bochesa, 1.6 for Abosa and 1.65 for Bashira Chefa (Table 6). Higher diversity was observed in the Bashira Chefa site (village in the Tulu Guddo Island), while others contributed relatively a smaller number of species diversity (H').

Table 6: Diversity status and number of fish species in different parts of the lake

	Sites			
	BG	Ab	BCh	Bc
Number of individuals (N)	347	350	325	338
Number of species	6	6	8	7
H’	1.5	1.6	1.65	1.5

Source: field survey

4.2 Demographic characteristics of respondents

Table 7: Demographic characteristics of respondents (n= 200).

Variables		study sites			
		Bekele Girisa	Abosa	BashraChefa	Bochesa
Gender	M	44	37	56	63
	F	-	-	-	-
	Total	44	37	56	63
Age groups (yrs.)	Below 20	8	11	10	9
	20-35	13	7	17	19
	36-45	18	17	20	29
	46-55	4	2	7	5
	Above 56	1	-	2	1
Marital status	Single	20	13	24	27
	Married	24	24	32	36
	Widowed	-	-	-	-
	Divorced	-	-	-	-
Religion	Orthodox	33	8	56	48
	Muslim	8	25	-	15

	Protestant	3	4	-	-
	Others	-	-	-	-
Ethnicity	Oromo	26	23	7	56
	Zay	-	-	42	6
	Amhara	11	10	6	-
	Gurage	7	4	1	-
	Others	-	-		1
Education level	Not read and write	6	2	5	1
	Primary (1-8)	36	33	44	56
	Secondary (9-12)	2	2	7	6
	Higher edu.	-	-	-	-
fishing experience (years)	1-20	30	31	36	39
	21-30	8	5	16	15
	31-40	6	1	3	4
	41 & above	-	-	1	5

Demographic characteristics of respondents

The information in the Table 7 shows that historically, fishing activity is linked to male gender. So, the researcher only interviewed people about this gender and this could be as a result of the many taboos relating to women's participation in fishing. Until recently when it was changed, a popular taboo in the study area is that women cannot be an occupant of fishing (personal communication). Thus, women were restricted to post harvest activities such as cooking, which, for them, is advantageous in being characterized by less risky. Also, from Table 7, the modal age range of respondents was 36-45 with that majority of the fisher folks are still in their active years with about 42%. This implies that majority of the respondents possess the physical agility to participate fully in sole or team fishing in the study area. On the same Table also shown the fact that majority of the fisher-folks (60.5%) was married. Being married entails some responsibility on the part of the man and the women. Thus, married adults probably engage in fishing so as to enable them have access to a steady income source to meet their obligations. Regarding education, about 84.5% were primary (1-8 grades) while that cannot read and write and attained secondary education were 7 and 8.5% respectively. Other information revealed in table above the most prominent religion in the study area was Orthodox with 72.5% and followed by 24.0% were Muslims. Only 3.5% were Protestants. The table also revealed that high percentages (about 56.0%) of the respondents were Oromo and 24.0, 13.5, 6.0 and 0.5% were Zay, Amhara, Gurage and Hadiya respectively. The Table also revealed that most of fishermen (68.0%) of them have

fishing experience between 1 to 20 years and 22.0% of them have between 21-30 years of fishing experience.

4.3 Traditional fishing methods and post-harvest activities

4.3.1 Traditional fishing methods

Artisanal fishing, defined as small-scale fishing where the fisherman's wealth is his fishing gear (boats, nets, and lines). They depend for their success on local and indigenous knowledge, much of which has been passed down from generation to generation through a strong oral tradition. Some of the indigenous fishing methods practiced among the fisher-folks during the present study was described as below:

4.3.1.1 Hand kicking

This method of fishing includes a fisher folk holds a long stick what is known as "Ule" in the local language. When there was rain, some fish species like African cat-fish come out of the lake to the surrounding wetlands. They have sub-brachial organs used for air-breathing (Johnels, 1957). The fishermen developed this knowledge that they know Cat-fishes come on land when there was rain. Then they came out to the shores of the lake and kick and kill the fish and then pick them. This kind of fishing was mostly practiced by fisher-folks at Bochesa site.

4.3.1.2 Pool- Trapping

This method was used around lakeshore where water pools are found. These pools were fenced with stones and a linking pipe type hole was dug that connects the pool with the lake. The fishermen know that fish liked pools for their warmth and they would congregate to the pool. During evening times, the fishermen would come and put trapping sack to the mouth of the hole that connects the pool and the lake. The fisherman would then enter to the pool and woo away the fish with a stick towards the sack. Thus, the fish would be trapped and enter into the sack (personal communication with a fisher folk at BashraChefasite, April, 2020). This fishing method was early used by the fishermen ofBashraChefaonly.

4.3.1.3 Hand-catching

This method is the oldest among other fishing methods and is practiced in rainy season. In the past, when there was an abundant and very bigger-sized fish, the traditional fishermen would often catch a fish from the shallow waters of the lake simply with their bare hands, without any net or hook. Bigger and male fish would often come to the shore and take rest. A

fisherman gingerly approaches the fish and instantly fall over the fish by jumping and catch it (personal communication).

4.3.2 Fishing gears

4.3.2.1 Seine net 'Tirmalla'

Seine net which is known as '*Tirmalla*' in local language is a hand operated net made up of hard nylon or cotton fibers (Fig.6 (a)). It is a relatively long net that stretches up to 200 meters. The floating buoy is tied at the one side of the net at a distance of one meter. A Radio beacon was used as a float. At the other side of the tirmalla,stoneswere tied as weight. The buoy floats while the stone sinks. As a result, the tirmalla stands between the floating buoy and the sunken stone thereby it becomes a wall so that any fish trying to cross it will end up wedged, gilled or entangled. The fisherman removes the catch in the following morning but might leave the net in the water for more catches. If necessary, he will change its location. The net usually stays in the lake for a long time. It has mesh size of 8-12cm (stretched mesh size), but sometimes less than this.

Fishes caught by this gear are larger or smaller sized fishes, but always larger fishes. The small fry fingerlings and juveniles fish scape to grow to larger size. It is set and operated by a single person who can set 1-3 Tirmalas at a time in different sites. Its catch size ranges from 15 to 200 fishes on one setting, but it depends on the sizes of the gears. There is no bait used to attract/lure fishes. Its advantage includes low cost of construction, maintenance, light weight, easy to operate and handle. This fishing method is the most widely used fishing method in all study communities (see table 8 below).

4.3.2.2 Hooks and lines or hand line, ''marfe''

In this method, a thin flexible bamboo rod tied with nylon thread fixed to a sharp metallic hook is used for fishing (Fig. 6 (b)). The principle of this kind of fishing is to offer natural bait to lure fishes that get hooked and then lifted. Generally, a bumble bee (*Bombus muscorum)* and termites (*Coptotermes formosanus*) were used as bait (Fig.6 (c)). Sometimes worms under roots of balsa tree are also used as bait. Residues of local drinks called *atela,* is used as bait in BashraChefa and Bochesa fishermen. A float of radio beacon with 3-4 cm was used to suspense the line. The baited hook is thrown in the water and the floats or thread lines used are observed for its movement. When baited hook is swallowed by fish, the thread is then with a little jerk. The fish is caught and hook engulfed by the fish is removed. This hooks and line fishing was most widely used fishing method next to tirmala by which (26%)

of respondents used it (see Table 8 below). It is set by a single person who can catch 1-10 fishes in mid-day times when the day is very hot. Fishes caught were Nile tilapia and sometimes *dubbae* (Crassius species)

4.3.2.3 Long lines 'Menteko'

This is a line with many hooks and is operated mainly during wet seasons (June to August). It is made of nylon or cotton twine of about 40-100 m long fixed with a series of baited hooks about 40-200 numbers at an interval of 2-3m on the main line which is stretched on the surface of the water. This kind of fishing is more practiced at BashraChefasite (see table 8 below) of the lake where the lake is deeper than other sites.

The operation of the gear is easy; here one end of the main line is tied firmly to a fixed pole and setting is continued with successive ties of the main line to the available weeds until the tail end is again tied to another fixed pole (fig.6 (d)). It is set early in the morning or in the first day and hauled after 8-10hrsor a day and reset again in the desired region. Species caught by this gear are the same as that of a line with single hook in addition to *Labeobarbus aethiopicus*. The most used baits are available insects, earthworms and non-edible smaller fishes called locally 'Boo'le' and or 'shulunku'. Now days, however, soap is also used as an attractant by some fishermen.

4.3.2.4 Hand net or ''ye ejimereb''

It is a handheld fishing net. The net is traditionally hand-woven from a cotton thread of one mm or more in diameter (fig.6 (e)). Nylon thread is sometimes used. Mesh size varies between nets, but is usually fine enough to hold even small fish. The net is circular in shape, and is typically two to three meters in diameter when intended to be used by a single fisherman. A rope of 6-7 meters long is attached to the center (or top end) of the net to cast it. A second rope is threaded around the perimeter of the net approximately 10 cm from the open wide end. The free 5 cm of net is then turned up inside the body of the net and stitched approximately every 15 cm to the outer mesh. Continuous pockets are thus formed around the bottom edge of the net which servesto confine the trapped fish. Pieces of stones tied to the perimeter of the net to weigh it. The weights are necessary for throwing the net, enable it to sink quickly, and close the open end when the net is retrieved with the catch. The net may be thrown blindly, or over visible fish, usually large ones. It is often used at night, when the fish are less disturbed by the presence of the fishermen. Usually, fishing is done from shore of the lake. The fisherman ties the free end of the throwing rope to his left wrist not to be thrown to the lake. Then half of the net is gathered over the left forearm, with the open weighted end

left hanging free. With the open end grasped in the right hand, the right arm, aided by the quick turning of the body from left to right, flings the spread net over the water. After the net settles, it is slowly pulled to the fisherman so that the weighted base of the net is drawn to a single point, thereby confining the fish. Then the fisherman carefully gathers the net with the fish on to his arm. In successful capture, the fisherman detaches the fish from the hook and stocks it in a sack or just pierces the softest part of its mouth with a rope through so that he can easily knot and hang it. Species caught by this gear include crucian carp, Nile tilapia, and common carps. This kind of fishing was practiced only in BashraChefa site of the lake (Table 9 below).

4.3.2.5 Wires or 'Shibo'

This kind of gear was made up of wires with u-shaped. The trap is thrown on the surface of water, with the open end facing upward into the water current. It is held in position using ropes tied from the open end to the shore, so that the person pools the trap (fig. 6 (f)). Fish that swept into the trap are unable to swim out against the current and the person collects them in to plastic bags.

There is also another type of this gear which is without the rope tied (fig.6 (g)). This gear is thrown on a water surface and a fisherman moves around the gear to disturb fishes so that they inter in-to the gear. Then the fisherman picks and stores them in a plastic bag.

This technique is used mainly in wet, during the breeding (migratory) season. It catches any fish of suitable size. However, the most commonly caught species were Nile tilapia, common carps and crucian carps. A person can catch an average of 7-10 fishes per hour by using this trap. The only fishermen using this kind of trap were found in Bochesa site (Table 8 below) and most of the time youngsters aged between 12-17 years were engaged in this task.

(a) (b) (c)

(d) (e)(f) (g)

Fig. 6: Different fishing gears and methods

(a)Tirmala, (b) a boy using hand line, (c) a baited hook with termites (*Coptotermesformosanus*), (d) a man collecting fishes caught by long line, (e) a hand net, (f) a boy pooling shibo, (g) boysholdinganon-tide shibo

Table 8: Number of respondents using different gears

Names of gears	Local terms	Number of fishermen using these gears in each site (n=200)				
		BekeleGirisa	Abosa	Bashra Chefa	Bochesa	Total
Seine net	*'Tirmala'*	29	24	35	32	120 (60%)
Hand lines	*'ye ejimarfe'*	13	12	7	20	52 (26%)
Hand net	*'ye ejimereb'*	-	-	2	-	2 (1.00%)
Shibo	*'Shibo'*	-	-	-	10	10 (5.00%)
Long lines	*'Menteko'*	2	1	12	1	16 (8.00%)

Source: field survey

As indicated in the Table 8 above, most (60%) fishermen used *Tirmala*and followed by (26%) of the fishermen who used hand lines. The least used fishing gears in the study area were hand net andshibo or wires with both less than 6%.

Table9: The mesh sizes of seine net, '*tirmala'* used by respondents

Mesh sizes	Number of respondents (n=200)	Percentages
Blow 8 cm	40	20
8-10 cm	122	61
Above 10 cm	38	19

Source: field survey

As it was indicated in the Table 9 above, most (61%) of respondents used correct mesh sized (8-10cm) tirmala to catch their fishes and 20% of them used illegal (below 8cm) mesh sized tirmala and 19% of them used tirmala with mesh sizes above 10 cm.

4.3.3 Fishing crafts

4.3.3.1 Raft or 'Yebela'

Raft or *'Yabala'*(fig 7 (a))in local language is a low weigh traditional fishing craft locally made from a plant grow on the shores of the lake known as papyrus or *Gubo* in the local language (Oromo). The fishermen cut and dry the raft in the sun until its low weight (fig 7 (b)). Then, they tie enough amounts of the dried rafts togetherwith one or two larges dried '*bofe'*(balsa tree) at its center. This increases its buoyancy on the water surface. It is used to navigate a person or occasionally two persons who catch fish by using hooks and lines lines and *tirmala*.This type of craft is the most used type of craft by 69% of fishermen (table 10).This is due to the availability of the material in the areas.

4.3.3.2 Canoe 'Bofe'

Canoe or 'Bofe' **(**fig. 7 (c)**)** was a traditional fishing craft made from 5-7 dried *bofe*trees, *Aeschynomeneelaphroxylon***(**fig.8(d)**)** tied together. First, the bofe were cut and dried for 2-3 weeks until to their low weight. Then these dried woods are tied together by adding some plastic bottles at its center. It holds a single fisherman who catches fishes using hooks and lines and *tirmala* (seine net).

4.3.3.3 Manual wooden boats

This craft was locally known as '*Zeway boat'* made manually from timbers of low weigh pants such as 'Wanza' (*Cordia Africana*) and or 'Bahrizaf' or Eucalyptus (fig. 7e). It is used to navigate a person that set *tirmala*, or seine net. It is also used by the fisherman catching fishes by using hooks and lines.

(a) (b) (c)

(d) (e)

Fig. 7: Fishing crafts and what they made from

(a) Raft or *Yebela*, (b)dried raft in the shore of the lake for next uses, (c) Canoe or *Bofe*,(d) Balsa tree or *Gubo* (e) Boat or '*YeZewayJelba'*

Table 10: Number respondents using different kinds of crafts

Name of crafts	Local terms	Number of fishermen using this craft(n=200)
Raft	*Yebela*	138 (69%)
Canoe	*Bofe*	47 (23.5%)
Manual wooden boats	*Ye Zeway Jelba*	15 (7.5%)

Source: field survey

As indicated in the Table 10 above, most fishermen (69%) of them used Raft or Yebela for fishing by using tirmala and hand lines. Others, (23.5%) of them used canoe or Bofe and the rest (7.5%) of them used manual wooden boats.

4.4 Post-harvest activities

4.4.1 Modes of fish processing

The fishermen perform traditional fish processing such as scaling, gutting and filleting. There are blades for doing fillets and use stones as a cutting board (see fig.8 (a)). Both men and women are involved in the process. However, women are mainly observed to prepare and sell processed fish such as soap, *tibs* or 'cooked fish' and *asa lebleb* or lightly cooked fish near the shores of the lake (fig.8 (b)). Men were engaged in fillet preparation (fig. 8 (c) and (d)). Peoples use the fresh and coocked products of fish dishes in the shores of the lake (fig. 8 (e). To preserve fishes for a long time, fishes are usually driedwith the salt added. Large fish are

split along the ventral midline (large-scaled fish are scaled beforehand), and the spread inner surfaces are exposed to the sun. Alternatively, a stick somewhat longer than the fish, is inserted in the mouth and out the vent. The fish may then be dried in the sun or over a fire. For drying over a fire, a thin rope is tightly stretched about two meters above the fire, and each fish is hung on the rope by its gill operculum. According to informants, these methods make fish meat stay for 4-5 days, even weeks (not more than two).

(a) (b) (c)

(d) (e)

Fig. 8: Fish dish preparation and using it

(a) Using stone as a cutting board, (b) A woman preparing fish soap and *asa tibs*, (c) Men preparing fish fillet in the lake shores, (d) prepared fillet (e) people using different fish dishes in the shores of thelake

Table 11: Percentages of respondents on preferences of fish dishes

Fish dish	local terms	Number of respondents using these dishes (n=200)				
		BG	Ab	BCh	Bc	Total
Roughly cooked fish	*Asa lebleb*	4	7	3	9	23 (11.5%)
fillet to be eaten raw	*Filleto*	6	3	12	18	39 (19.5%)
Fish soup	*Asa shorba*	8	10	9	22	49 (24.5%)
Roasted fish	*Kuanta*	5	1	6	8	20 (10.0%)
Fish strew	*Asa wet*	21	16	26	6	69 (34.5%)

Source: fieldsurvey

As indicated in the Table 11 above, most (34.5%) of respondents prefer eating fish strew and followed by fish soup by which 24.5% of the respondents prefer it. Two fish dishes such as *kuanta* which is a dried fish product, and *asa lebleb* were the least used fish dishes in the study area.

4.4.2 Modes of transportation and marketing

After landing, the fishes were sorted on the shore and auctioned. Some fishes (filleted or the whole fish) not sold at the shores are carried un-iced from the landing centers to nearby markets or shops (fig.9 (a)) usually using motor-bikes, bicycles, their bare feet and tong as or by head load (see fig.9 (b, c and d)).

Table 12: Number of respondents on where they sell their fishes

Places	number of respondents (n=200)
On the shores	148 (74%)
Nearby shops	23 (11.5%)
Local markets	29 (14.5%)

Source: field survey

According to fishermen, the price for fish differs per species (whole or filleted) and fluctuates depending on the fasting and non-fasting period. In general, filleted fish (33-38 % of the whole fish) catches a better price on the market than the shore. The price of catfish depends on the place of selling. As indicated in the Table 12 above, most (74%) of the fishermen compel to sell their fishes near shore. Others, 14.5 and 11.5 % of them sell their fishes in

local markets and nearby shops respectively. In general, catfish is not a preferred fish species in all study areas. This is due to catfish have no scales and are considered a forbidden fish for religious reasons. Some (especially elderly) people do not want to eat these fish because they are not used to it or because of its features (personal communication).

(a) (b) (c) (d)

Fig. 9: Modes of transformation and marketing

(a) Fish shop near to Zeway Fishery and Research center, (b) a boy carried fishes by head load, (c) Childs taking fishes from Bochesato local market, (d) Bicycle for fish transportation

4.5 Indigenous knowledge on Biological attributes of fishes

4.5.1 Sex categorization

Fishermen in study areas developed the following characteristic features to identify male fishes from females:

Table 13: Distinguishing features used by fisherfolks to identify sexes of fishes

Characters	Males	Females
Color	Pale dark and attractive	looked slime, whitish color
Size	Long, thin and heavy	thicker than males but lighter
Genitals	Out growing	in growing (thin holes)
	Emits a sort of urine if pressed	stuff eggs on her mouth when caught
Behavior	Dig holes near to shores	move around the holes

As described above in the Table 13, male fishes are identified by their heavy body mass, thin and long, pale attractive color, out growing reproductive parts. When they looked a typical fish dig holes near to shores of lake, they assume it as a male. On the otherhand, local fishermen believed that males emit a sort of urine when pressed. They identify females as

they looked slimy, thicker than males. They believe the stuffed mouth of females as they are ready to lay eggs.

4.5.2 Healthy vs. unhealthy fish

Local peoples developed some morphological characteristics that helped them to identify the healthy fish from unhealthy. They imagine that when fishes are sick, their belly become bulged, distorted or smooth body scales and their tongue become red in color, but the normal fishes have tongue with white color (personal communication).

4.5.3 Feeding habit

Examining the food and feeding habits of a species is important for evaluating the ecological role and position of the species in the food web of ecosystems (Hajisamae*et al*., 2003). Information also provides further support for fishers to know different fishing practices. In this study, fisher folks have categorized the fishes under herbivorous and carnivorous. This categorization is based on hooks and line fishing. According to this, fishes that hooked are carnivores whereas; those that not hooked are herbivores. If they have targeted to fish African cat fish and common carps, they use hooked gears and for others gill nets. But others estimate that there is no any demarcation in their feeding and they consume whatever they found like birds excrete, cow dung, worms, tadpoles, grasses, etc.

4.5.4 Fish as a folk medicine

The reliance on traditional uses of animals as food and as medicine by communities around the world highlights the need for further interdisciplinary research in ethnozoology (Alves, 2013). In addition to the importance of fish as food, it was known that the use of fish in traditional medicine. In communities around Lake Zeway, the use of animals, including fish, as medicinal resources are a fairly widespread and ancient phenomenon. Inall sampling areas, questioners cited two fish species used as medicine, the *Minch* (*Labeobarbus intermedius*) and tilapia (*Oreochromus niloticus*). These fishes are used to treat common cold, headache and fatigue (asthma). They also used their fat, which is warmed and rubbed if their body parts accidentally cut. These fish are targeted as a medicine because of historical adaptation to the species by the local people.

4.6 Traditional knowledge on species distribution

This knowledge is important to the organization and success of fishing activities. The fishers were found to have a broad knowledge of the distribution of fish species in the environment and their position in the water column, i.e., the depth the animals usually inhabit. Lake Zeway

fishermen have knowledge on distribution of different fishes in the water column of the lake (Table 14).

Table 14: The response of fishermen on ecology of fishes

Fishes	Number of respondents on ecology fishes in the lake (n= 200)	
	At the edge of lake	at the bottom of the lake
O. niloicus	161 (80.5%)	39 (19.5%)
C. zillii	170 (85%)	30 (15%)
C. carassius	25 (12.5%)	175 (87.5%)
C. carpio	38 (19%)	162 (81%)
E. paludinosus	102 (51%)	98 (49%)
L. intermedius	42 (21%)	158 (79%)
L. ethiopicus	33 (16.5%)	167 (83.5%)
C. gariepinus	56 (28%)	144 (72%)

As indicated in the Table 14above, most fishermen argued that two fish species such as *O. niloicus* and *C. zillii* dwell the edge of the lake, while a few claimed that these species live at the bottom of thelake. On the other hand, most fishermen appealed that five fish species such as *C. carassius, C. carpio, L. intermedius, L. aethiopicus* and *C. gariepinus* dwell the bottom of the lake, while a few claimed that these species live at the edge of the lake.

4.6.1 Indigenous knowledge on how fishermen know best fishingtime and grounds for their successful catch

This is one of the most important skills required by fishermen to capture more fishes and satisfies their needs. This skill is learned through experience. They know when to go for fishing to get more fishes. Most fisher-men go fishing when the sun is very hot at mid-day. Others go to fish when there are no wind waves at any time of a day. Some of the indicators they used to locate the best fishing grounds are described in Table 15 below.

Table 15: Number of fishermen using indicators to a successful fishcatch

Indicators	Number of respondents using this as an indicator(n=200)
Hippopotamus	21 (10.5%)
Wind direction	109 (54.5%)
Rain	62 (31.0%)
Flocks of Lake birds	8 (4.0%)

Source: Field survey

4.6.1.1Presence of hippopotamus indicates abundance of fishes

Looking for the location of other lake animals is an important indicator of best fishing areas by fisher folks. Traditional fishermen in some study sites believe that presence of hippopotamus (*Hippopotamus amphibious)* is an indication of abundance of fishes. When there is abundance of plankton in the coastal waters, hippos are attracted to that area. Then they eat grasses and other lake plants and excrete around there. The fishermen believed that the fish follow to feed on excrete of hippo's and accumulated in area where they found. Then they prefer fishing in these areas to get more fishes. As indicated in the table 15above, 10.5% of the fisherfolks use hippos as an indicator for successful catch.

4.6.1.2Presence of flock of lake birds as an indication of fishabundance

The traditional fishermen take the presence of large flocks of birds as an indication of fishes. When fishes approach the water surface near the shore, fish-eating birds like kadalkaakka (sea gull) and Great White Pelicans (*Pelecanus onocrotalus*) fly in large numbers over the waters in attempts to catch the fish. The appearance of these birds scooping into the water frequently indicates the presence of fish. This is why fishes gather birds' litter as their food and approach where there is a flock of birds. Then the fishermen take considerations to catch around these areas for the next days.

4.6.1.3 Wind direction as successful catch

The fisher folks relate the direction of wind blows with catch success. They believe that when air blows from west to east, more fishes caught. Others also assume that air blows from shore to lake increases catch success. As indicated in the table 15 above, most fishermen (54.5%) of the fisherfolks use wind direction as a successful catch.

4.6.1.4 Rain as an indicator of fishes

Rain is used as an indicator of some fish species. After a heavy rain, cat fishes come out to the shores of lake to search on their foods. Fisher folks go to shores of the lake after rainfall so that they have the knowledge they already know *Ambaza* comes out after heavy rain. Fishermen simply pick on the lookout for these fishes. Among the study sites, Bochesa fishermen use this knowledge. It was limited in other sites (table 15).

5. Discussion

A total of eight species of fishes in the Families Cichilidae, Cyprinidae and Clariidae were identified from the different landing sites of the lake (Table 3). Two species such as *Garra dembecha* and *Garra makiensis* which were recorded previously (Getahun and Stiassny, 1998; Abera, 2006; Golubtsov*et al*, 2002) are not recorded in the present study. This is due to first, the samples were collected exhaustively from the fishermen catch and they only used suitable nets for their livelihood catch so that the species were not caught by these nets. Second, even the above author's record these species, they got them very few in number and even they argued that the species are on the verge of extinction. Third, fishes were recorded only at certain landing sites and not from the multiple landing sites of the lake and this may also result in certain fishes not to be caught. *Labeobarbus intermedius* which is available in the whole sampling sites during the previous study (Golubtsov *et al*, 2002, Abera, 2016) was found very rare in this study. The species was only caught from BashiraChefa (an is-land to the East of lake) and only one species caught from Bochesa (South West of the lake) during the survey periods of this study (Table 3). *Labeobarbus aethiopicus*, which is endemic species of Lake Zeway in Ethiopia (Golubtsov *et al.*, 2002) was very rare in the lake during the present study. They were only recorded from BashiraChefa site and even there, it was very few in numbers. This might be due to ecological changes on the shore of the lake in particular, such as decreasing phytoplankton production due to siltation and degradation of shoreline vegetation.

During this study, Cyprinidae relatively dominated the fish composition of the lake as had previously been observed in the study area (Abera, 2016). This family is also abundant countrywideinsurvey taken by Getahun and Stiassny, 1998. This condition may be due to a high tolerance of these fishes to turbidity variation of the lake (Getahun and Stiassny, 1998; Abera, 2016). At species level, *O. niloticus* was the dominant fish species from the Family Cichilidae as well as the whole species from the lake and it accounts to 38.16 % of the total catch. The dominance of this species over other species in the lake may be attributed to

several factors including adaptation to the habitat, flexible feeding habit and fast growth rates (Njiru *et al*. 2008). However, the contribution of the fish has been gradually declined from 94% (Schroder, 1984), 89.3 % (Mathewos Hailu, 2013), 42 % (Abera *et al*., 2014b) to 38.16% in present study. This is because the species suffers from stunted growth caused by stress; probably due to a combination of low water levels, reduced breeding grounds and too high fishing pressure (Abera, *et al*., 2014a). In addition, *C. zillii* was abundant in Abosa (Western) and Bekele Grisa (North-Western) part of the lake than the rest of two sites. This is because in these two areas, there was vegetation cover in its shore. This is also evident in that this species are more dependent on shore line habitat with dense vegetation cover (their habitat preferences to macrophyte feeding habit) (Lowe-McConnell, 1987).

Larger and shallow lakes are potentially expected to have a wider range of habitats than smaller lakes (Toivonen and Huttunen, 1995). However, in Lake Zeway, higher turbidity, fluctuations in water level and other factors seem to limit the fish diversity to mainly turbidity- tolerant species, for example the two carp species and *C. gariepinus*. Fish species diversity of Lake Zeway during the present study was almost equal (H′ value in between 1.5 to 1.65 on different sites) compared with some published data on lake (H' value in between 1.5127 to1.6681) (Abera, 2016).

Higher numbers of fish specimens were caught in wet season than dry season during the present study (Table 5). This is due to the fishes were in breeding time that high chance to captured with fishing gears. This is in agreement with results of Assefa Tessema et al. (2012) and Welcomme (1985). There was decline of the native fish species in Lake Zeway. This has been attributed to predation of these species by the introduced *C. gariepinus*, other bottom feeder species like *C. carpio* and *C. carassius* that affect the breeding area and to some extent destruction of spawning and nursery grounds through human encroachment (Golubtsov *et al*., 2017; Abera, 2016). Ogutu-Owayo et al. (1991) also confirmed this on the study on Lake Kyoga, Keniya. Hence, results of this study revealed that the native species of Lake Zeway especially *L. aethopicus* and *L. intermedius* may have now become threatened and other exotic species like *C. carpio* and *C. carassius* were now occurring in almost all parts of the lake and have increased in biomass than the threatened species.

In general, low diversity is expected in lakes that have an outflow, because accumulated nutrients produced from different sources could be flushed out (Burlakoti and Karmacharya, 2004).In addition, the absence of significant heterogeneity among sites can also induce lower diversity of fishes (Abera, 2016). Sylvester and John (2010) also reported that homogeneity

of habitats favored lower diversity of fishes in water courses of Uganda. During this study, relativelyhigher diversity of fishes was observed in Bashira Chefa site (Table 6). This can be as a result of high flood water in the area. Flood waters are important because the flooding of lateral plains increase the area of food rich habitat and shelter from predators. They also provide ideal site for fish to develop and grow unless the area was degraded (Welcomme, 1979).

On the other hand, fishermen around Lake Zeway used some traditional fishing methods to catch fishes for their livelihood and nutritional security. The study indicated that a diverse range of fishing gears and crafts have been evolved over a long period by the fishermen to capture a wide range of fish species in these areas. Among the fishing crafts, yabala was the most used craft by 69% of fishermen (Table 10). It is due to the availability of the material in the areas. This is in line with the findings of Mberengwa and Bacha (2011) a study undertook in Ethiopia on the role of fishery in livelihood security of fishing communities around Lake Zeway by which most (50.4%) of the respondents used this craft. These fishing tools were made manually from local materials. This indicates using local materials helped fishermen not to purchase the expensive materials or cost of craft and gear construction is less as they are made up of locally available material. Since no technical skill is required and fishermen are easily adapted to the operation of these indigenous crafts and gears.

As indicated in the Table 11, most (34.5%) respondents prefer eating fish strew and followed by fish soup (24.5%). Others were least used fish dishes in the study area. This is due to most fishermen have not access to basic cold chains with ice and insulated containers so that peoples prepare their fishes to eat in cooked form. In general, catfish is not a preferred fish species in all study areas. This is due to catfish have no scales and are considered a forbidden fish for religious reasons. Some (especially elderly) people do not want to eat these fish because they are not used to it or because of its features (personal communication). As indicated in the Table 12, most (74%) of the fishermen compel to sell their fishes near shore. This is due the fishermen especially at Bashra Chefa and Bochesa site lack transport access to market chain and shops.

As described above in the Table 13, fishermen in the study areas developed some characteristic features to identify male fishes from females. Male fishes are identified by their heavy body mass, thin and long, pale attractive color, out growing reproductive parts. When they looked a typical fish dig holes near to shores of lake, they assume it as a male. This is a way that the male fishes do a characteristic action to attract females for mating. Some fish

species e.g., males of *O. niloticus* constructs and defends a mating territory with other males (Mendonca *et al*., 2008). On the other hand, they believe that males emit a sort of urine when pressed. They identify females as they looked slimy, thicker than males. They believe the stuffed mouth of females as they are ready to lay eggs. This is also true that female fishes hold their eggs to provide parental care. For example, females of *O. niloticus* are maternal mouth brooder (Mendonca *et al*., 2008).

Ecological, historical and socio-cultural aspects related to fish and fishing developed by local fishermen shows clearly the value of this ecological and cultural knowledge provides a necessary base for sustainable management of the fishery resources of the area. This knowledge is also important to the organization and success of fishing activities. The fishers were found to have a broad knowledge of the distribution of fish species in the environment and their position in the water column, i.e., the depth the animals usually inhabit. This information is important when choosing the fishing gear to be used and for selecting the target species. In Lake Zeway, fishermen have knowledge on distribution of different fishes in the water column of the lake (Table 14). On the otherhands, fisher-folks in the areas used indicators such as some lake birds and animals, wind direction and rain to a sucessiful catch (table 15). A study by Sahadevan (2016) indicated that peoples used Whales as an indication of high number of fishes in Kerala (South India). This information is also important when choosing the fishing gear to be used and for selecting the target species and target areas to fish.

The area sustains important fish fauna diversity and local people have inherited a considerable traditional knowledge that helps them to identify these species which is base line knowledge and what the researcher have been used this to identify the fish species in the field.

6. Conclusion and recommendation

6.1 Conclusion

A total of 1360 fish specimens were recorded from the three families Cichilidae, Cyprinidae and Clariidae during the study period. The species were: *O. niloticus* and *T. zillii* from the family Cichilidae (46.10%); *C. carassius, C. carpio, B. paludinosus, L. intermedius* and *L. aethiopicus* from the family Cyprinidae (47.80%); and only *C. gariepinus* from the family Clariidae which accounts 6.10%. During this study, Cyprinidae relatively dominated the fish composition of the lake. However, two species such as *Garra dembecha* and *Garra makiensis* which were recorded previously are not recorded in the present study. This is due to the fish samples were recorded only from limited landing sites of the lake and gears used were commercial. Fishes recorded only at certain landing sites decreased fish diversity.

Present study also concludes that the ichthyofaunal resources of the Lake Zeway are an important component of Lake's biodiversity and are an important source of food and income source for fishermen communities. From the present study it is also evident that, there is no destructive fishing in this area, except some fishermen use nets with meshes size less than 8 cm. Fishermen in Lake Zeway were using indigenous methods for fishing which is greatly contributing to the sustainability of the lake fishery. There was indigenous knowledge possessed by fisher folks of the study areas. This knowledge is important when choosing the fishing gear to be used and for selecting the target species. The overall results revealed that the conservation of indigenous knowledge along with the introduction of technical knowledge can lead to overall growth and development of the fisheries sector of the area.

6.2 Recommendations

- Some fishes'speciese.g., *L. intermedius*; which was abundant in the whole samling sites in previous studies were very rare in the present study. To take management measure of this species and others, detailed studies and investigations are required on status and trends of fishes in rift valley basin in general due to high pressure of degradation of the area as well as ecological issues specially that of catchment of the lakes
- The results of the present study show that there is no any area closure to fishing. Therefore, delegating some of the decision marking especially area closures and entry limitations to local communities should be organized in the area

- IK and scientific or technical or western knowledge should be integrated for the benefit of humans. This integration will enhance mutual learning by reducing knowledge gaps between rural producers of communities around L. Zewaywho are the target end-users of research outcomes
- Changes in the composition of catches and the diversity of fishing methods should be monitored systematically on the L. Zeway over the coming years to check if there is anything that has a profound cultural and socio-economic impacts on the local populations that depend on fishery resources

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Appendices

Appendix 1 Questionnaires in Amharic

ለአሳ አጥማጆች የተዘጋጁ መጠይቆች

ውድ መጠይቅ! እነዚህ መጠይቆች ስለ ዓሳ ማጥመጃ ዘዴዎች እና ስለመኸር መሰብሰብ ሥራዎች፣ባህላዊ እደ-ጥበባት ዓሳዎችን ለመያዝ የሚያገለግሉ ቁሳቁሶች መረጃ ለመሰብሰብ የተዘጋጀ ነዉ። የአሳ ማጥመጃ ሀብቶችን ለማቆየት የሚያስችሉ እርምጃዎችን ለመጥቀስ እንዲሁም ፖሊሲ አውጪዎች በሀይቁ ዓሳ ላይ በመመርኮዝ የአሳ ሀብትን በዘላቂነት እንዲጠብቁት ባህላዊ ዕውቀትን ለማበረታታት እና ለመደገፍ ግብዓት ለማቅረብ ይጠቅማሉ። የተሰበሰበው መረጃ ለምርምር ሥራ ብቻ የታሰበ መሆኑን ተመራማሪው ያረጋግጣል።

ስምዎን መጻፍ አያስፈልግም

ስለ ጊዜዎ እና ጠቃሚ መረጃዎ እናመሰግናለን!!

የመጠይቆች የግል መረጃ

1. ፆታ- ወንድ ☐ ሴት ☐

2. ዕድሜ- ከ 20 በታች ☐ከ 20-35 ☐ ከ 36-45 ☐ ከ 46-55 ☐ከ 56 በላይ ☐

3. የጋብቻ ሁኔታ- ባለ ትዳር ☐ መበለት ☐ የነጠላነት ፍቺ ☐

4. የትምህርትደረጃ- ማንበብ እና መጻፍ የማይችል ☐ አንደኛ ደረጃ (1-8) ☐

ሁለተኛ ደረጃ (9-12) ☐ ከፍተኛ የትምህርት ደረጃ ☐

5. ጎሳ- ኦሮሞ ☐ዘይ ☐አማራ ☐ጉራጌ ☐ ሌሎች ☐

6. ሃይማኖት- ኦርቶዶክስ ☐ ሙስሊም☐ ፕሮቴስታንት ☐ሌሎች ☐

7. የአሳ ማጥመድ ልምድ (በዓመታት) - ከ 1-10 ☐ ከ 11-20 ☐ ከ21-30 ☐ 31 እና ከዚያ በላይ ☐

በአሳ ማጥመድ ልምዶች / ዘዴዎች ላይ ስለ ባህላዊ እዉቀት ጥያቄዎች

1. ዓሦዎችን ለማጥመድ ከሚጠቀሙባቸው የቲርማላ ቀዳዳ ስፋት የትኛው ነው? ከ 8 ሴ.ሜ በታች ☐ 8-10 ሴ.ሜ መሃል ☐ 10 ሴ.ሜ እና ከዛ በላይ ☐

2. የአሳ ማጥመጃ ቁሳቁሶች የሚሠሩት ከምንድነው? እባክዎን ይጥቀሱ።

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3. እነዚህን ማጥመጃ ቁሳቁሶች እንዴት ይሠራሉ? እባክዎን በአጭሩ ያስረዱ እና ለመገንባት ምን ያህል ጊዜ እንደሚወስድም ይንገሩ .....

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4. የአሳ ማጥመጃ ቁሳቁሶች የሥራ ዕድሜ (በወራቶች/ዓመታት) ምን ያህል ነው? ……

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5. በሚይዙበት ጊዜ ዓሦችን ለመሳብ / ለመባባል የትኞቹን መሳሪያዎች / ማጥመጃዎች ይጠቀማሉ (ስነ-ዘዴዎቹ የጎንዮሽ ጉዳቱ አዎንታዊ ወይም አሉታዊ ነው) .....

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6. በሐይቁ ሀብት ስጋት የሆኑ ባህላዊ የአሳ ማጥመጃ ዘዴዎች / መሣሪያዎች አሉ ብለው ያስባሉ? አዎ☐ አይ☐ አዎ ከሆነ እባክዎን ዘርዝሯቸው እና ምክንያቱን ይግለጹ

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7. የመያዣ ዝርዝሮች-የሚይዙየአሳ ማጥመጃ ቁሳቁሶች በጊዜ ወይም በአሳ ዝርያዎች የተወሰኑ ወይም የተለዩ ናቸው? ለምን እንደሆነ ያብራሩ .....

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8. የሐይቁ የማእበል እንቅስቃሴ ስኬታማ አሳ የመያዝ እድልን የሚወስኑ ምክንያቶች ሊሆኑይችላልን? አዎ☐አይ ☐አዎ ከሆነ እንዴት? .....

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9. የኖና የአሳ ማጥመጃ መሣሪያ ለመስራት ስንት ግለሰቦች ይሰማራሉ?.....

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10. የሚጠቀሙባቸው ኣሳ ማጥመጃዎች- የእጅ መንጠቆ ☐ የእጅ መረብ ☐ ሺቦ ☐ ትልቁ መንጠቆ☐

11. ዓሣ ለማጥመድ ዉኃ ዉስጥ ለመሄድ የትኛውን ይጠቀማሉ? ያበላ ☐ ቦፌ ☐ የዝዋይ ጀልባ ☐ ሌሎች ☐

12. የአሳ ማጥመጃ ቁሳቁሶች የማሻሻያ ወሰን-ሌሎች የውሃ ውስጥ ያልተፈለጉ ለምሳሌ እንስሳት / እጽዋት በመያዝ እንደ ሪፖርት የተደረጉት ምንድናቸው? ይህንን ችግር ለመቅረፍ ቁሳቁሶቹ እንዴት ይሠራሉ?

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13. በሀይቁ ላይ ያሉትን ምርጥ የዓሣ ማጥመጃ ቦታዎች (ጣቢያዎች) እንዴት ያውቃሉ? በጣም አስፈላጊ አመልካቾች ምንድናቸው? እባክዎን ያብራሩ፤ ……
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በድህረ-ተግባራት ላይ መጠይቆች

1. ዓሣ ከጠመዱ በኋላ ዓሣ ስጋ ለቢዙ ጊዜያት ለማቆያት ከፈለጉ የሚጠቀሙ ባህላዊ መንገዶች የትኛው ነዉ? መጥበሰ ☐ በፀሐይ ማድረቅ ☐ በጨው መለወስ ☐ሌሎች ☐

2. የዓሳ ምግቦች ምርጫ (ከአንድ በላይ መምረጥ ይችላሉ) - ዓሣ ለብለብ ☐ ጥሬ ዓሣ ☐ የዓሳ ☐ ሾርባ ☐

የዓሳ ጥብስ ☐ የአሳ ወጥ ☐

3. ዓሳዎን እንዴት ይሸጣሉ? ሙሉውን ☐ ፍሌት በመስራት ☐ በማብሰል ☐

4. ዓሳዎን የት ይሸጣሉ? በሐይቁ ዳርቻ☐ በአቅራቢያው በሚገኙት ሱቆች☐ በአቅራቢያ ገበያዎች ☐

5. ዓሳዎን ለማጓጓዝ የሚጠቀሙ ተሽከርካሪዎች / የትራንስፖርት መንገዶች- ባዶ እግር☐ ሞተር ☐ ብስክሌቶች ☐ ብስክሌቶች ጋሪዎች ☐ ሌሎች ☐

6. ለኑሮዎ ብዙውን ጊዜ ፍላጎት ያሎት በየትኞቹ የዓሣ ዓይነቶች ላይ ነው? (ከሁለት በላይ መምረጥ ይችላሉ) ፤ ቆሮሶ ☐ አምባዛ ☐ ጃፔ ☐ ዱቤ ☐ አድሴ/ኬንያ☐ ምንጭ☐ አጥንታሙ ምንጭ☐

7. በዚህ ሐይቅ ውስጥ የማይበሉ የዓሣ ዝርያዎች አሉ? ካሉ ስማቸውን ይፃፉ እና ለመብላት ለምን እንዳልተፈለጉ ይንገሩ.....

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ሥነ-ምህዳራዊ እውቀት ላይ መጠይቆች

1. ከፍተኛውን የዓሣ ማጥመጃ ወቅት ይንገሩ እና ለምን እንደሆነ ያብራሩ

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2. ስለ ዝርያ ስርጭት ፣ ፍልሰት ፣ ባህሪ ፣ ወዘተ ባህላዊ ዕውቀትን መመርመር (ስለ ዝርያዎች ስነምህዳራዊ እና ስነምህዳራዊ ባህሪዎች ያለዎት እውቀት)

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3. የአየር ንብረት ሁኔታዎችን እንዴት ይዛመዳሉ - የዝናብ መጠን ፣ ደመና ፣ የሙቀት መጠን እና ነፋስ ወዘተ? እነዚህ አካላት ከዓሳ ሀብቶች አጠቃቀም ጋር እንዴት ይዛመዳሉ? .....

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4. የእያንዳንዱን የዓሣ ዝርያ ቦታ (በጥልቀት ፣ በባህር ዳርቻ ፣ ወዘተ) ያውቃሉ? እንዴት?.....

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5. የጨረቃ ደረጃዎች (አዲስ ጨረቃ ፣ የመጀመሪያ ሩብ ፣ ሁለተኛ ሩብ እና ሙሉ ጨረቃ) ስኬታማ ዓሣ የመያዝ እድል ላይ እንዴት ሚና ይጫወታሉ? .....

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6. ዓሣ በማጥመድ ጊዜዎ በአካባቢው የቀነሰ / የጠፋ የዓሣ ዝርያ እንዳለ ያውቃሉ? አዎ የለም አዎ ከሆነ ዝርያውን ይግለጹ ……

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7. ዓሣ በማጥመድዎ ወቅት የጨመሩበት የዓሣ ዝርያ እንዳለ ያውቃሉ? አዎ ☐አይ ☐

8. ዓሳ ለመሄድ በቀን / በወር / ልዩ ጊዜ አለዉ? አዎ ☐ የለም☐ አዎ ከሆነ; መቼ ፣ ለምን?

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9. በጣም ጥሩውን የዓሣ ማጥመጃ ጣቢያ እንዴት ያውቃሉ? እባክዎን ለአመላካቾችን ያስረዱ

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10. ትናንሽ ዓሳዎችን ሲይዙ ምን ያደርጋሉ? .....

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11. ለማራባት ዝግጁ የሆነ ዓሳ ሲይዙስ?

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12. በዚህ አካባቢ ዓሦችን ለማጥመድ ጊዜያዊ ውስንነቶች እና አከባቢ መዘጋት አለ? አዎ☐

የለም ☐

13. በሐይቁ ውስጥ ስንት የዓሣ ዝርያዎች ይገኛሉ?

ከአምስት ዓመት በፊት ……..

በአሁኑ ወቅት ……..

ስለ ዓሦች ባዮሎጂካዊ ባህሪዎች መጠይቆች

1. የዓሳዎችን ፆታ እንዴት እንደሚለዩ ያስረዱ……

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……

……

2. የታመሙ ዓሦዎችን ከጤናማ ዓሦዎች እንዴት ለይተው ያውቃሉ? እባክዎን ያብራሩ .....

Appendix 2: Questionnaires in English

Dear questionnaire! these questionnaires have been developed to collect data about fishing methods and post-harvest activities, traditional crafts and gears used to catch fish, traditional knowledge on species distribution, migration, behavior, etc. applied in these areas to suggest measures in order to conserve the fishery resources and to serve an input for the policy makers to encourage and support indigenous knowledge for sustainable utilization of fisheries resource thereby improving livelihood of the community depending on the lake fishery. The researcher assures that the information gathered is intended for research purpose only.

No need of writing your name

Thank you for your time and valuable information!!

Fishing site.....

Personal Information of the respondents

1. Gender: Male ☐ Female ☐
2. Age: blow 20 ☐ 20-35 ☐ 36-45 ☐ 46-55 ☐ Above 55 ☐
3. Marital status: singled ☐ Married ☐ Widowed ☐ divorced ☐
4. Educational level: not read & write ☐ primary school (1-8) ☐
   2dry School (9-12) ☐ higher education ☐

5. Ethnicity: Oromo ☐ Zay ☐ Gurage ☐ Amhara ☐ Others ☐
6. Religion: Orthodox ☐ Muslim ☐ Protestant ☐ others ☐
7. Fishing experience (in years): 1-10 ☐ 11-20 ☐ 21-30 ☐ 31 & above ☐

Questions about IK on fishing practices/methods

1. Which of the mesh sizes of *Tirmala* you use to catch fishes? Below 8cm ☐ 8-10cm ☐ above 10cm ☐
2. Fishing Gears you are using: Hooks and lines ☐ hand lines ☐ seine net ☐ hand net ☐ shibo ☐ others ☐
3. How do you operate these gears? Please explain briefly and tell how long it takes to construct……..
   …….

4. How much is the operational life span of the gears (moths, years)? .....
   .....
   .....
5. What devices/ bait would you use to attract/lure fish during catching and state their side effects (positive or negative on the lake and fishery resources) ……
   ……..
   .....
6. Do you think that there are traditional fishing methods/tools that are a threat to sustainable fishing of the lake? YES ☐ NO ☐
   If yes please list them and give the reason.....
   ……
   ……..
7. Catch details: Are the catching gears time and/or species specific to set? Explain why it is so.....
   ……
   ……
   ……..
8. Are the movements of Lake Tides can be factors regulating the likelihood of a successful catch? Yes ☐ No ☐ If yes, how? .....
   .....
   .....
9. How many individuals are requested to operate a typical gear?
10. Fishing Crafts you are using Yabala ☐ Bofe ☐ Zeway Jelba ☐ others ☐
11. Scope of upgradation of the gear: what are other aquatic animals/plants are reported as by catch? How the gears are designed to minimize this problem?
    .....
    .....
    .....
12. How do you know the best fishing grounds (sites) on the Lake? What are the most significant indicators? .....
    ……
    ……

Questionnaires on Post-harvest activities

1. What are the traditional ways of post-fishing practices used to preserve the fish?

Salting ☐ sun drying ☐ roasting ☐ others ☐

2. What is the preference trend of fish's dishes? (You can choose more than one): Roughly cooked fish or *Asa lebleb* ☐ fillet to be eaten raw or *'Filleto* ☐ Fish soap *'Asa shorba'* ☐

   Roasted fish *'Kuanta'* ☐ Fish strew *'Asa wet'* ☐

3. How do you sell your fishes? Whole ☐ by filleting ☐ by cooking ☐

4. Where do you sell your fishes? Near shore ☐ nearby shops ☐ local markets ☐

5. Vehicles/means of transportation used to transport your fishes: bare foot ☐ motor bikes ☐ bicycles ☐ Carts ☐ Others ☐

6. Which types of fish species you are usually interested on for your livelihood? You can rate more than two. *Nile tilapia* or '*koroso*' ☐ Cat fish or '*Ambaza*' ☐ common carps or *Jape* ☐

   Carassius carassius or '*Dube*' ☐ *Coptodon zillii* or '*kefkefe'* ☐

7. Are there non-eaten fish species in this lake? If any, write their names and tell why they are ignored to eat? ……

Questionnaires on ecological knowledge

1. Tell the peak fishing season and explain why.....
2. Probe for traditional knowledge on species distribution, migration, behavior, etc. (Knowledge that you have of the biological and ecological attributes of species).

   ……

   ……

   ……
3. How do you relate climatic conditions - rainfall, clouds, temperature, and wind, etc.? How are these elements related to the use of the fish resources?.....

   ……

   ……
4. Do you know the location of each fish species (in depth, shore, etc.)? How?.....

   ……

   ……
5. How the lunar phases (new moon, first quarter, second quarter, and full moon); play a role in catch success? .....

   ……

   ……

6. Do you know of any fish species in the area that had declined/disappeared during the time you have been fishing? Yes ☐ No ☐ if yes, state the species……..……
7. Do you know of any fish species in the area that had increased during the time you have been fishing? Yes ☐ No ☐
8. Is there a special time of day/month/ to go fish? Yes ☐ No ☐ If yes; when, why?
   .....
   .....
   .....
9. How do you know the best fishing site? Rate the indicators……
   Flock of birds ☐ rain ☐ hippos ☐ wind direction ☐
10. What will you do when you catch small fish?
    ……
    ……
11. What about when you catch a ready to spawn fish?.....
12. Is there an area closure and entery limitation to fish? Yes ☐ No ☐
13. How many fish species are found in the lake?
    Before five years ago ……
    Present days…….

Questionnaires on Biological attributes of fishes

1. Explain how do you identify sexes of fishes……

……

2. Explain how do you describe heath of fishes?.....

……..

Appendix 3: Observation Guide

Information about the local community

Fishing site.....

Fishing practices

Traditional crafts and gears used for fishing,

Traditional methods used for fishing

How and from what materials they make the fishing tools

How they use the tools

Most used gears, the least used one

Indigenous knowledge practices

IK fishing practice availability

IK fishing practice indicators

Cultural implication for IK fishing practices

Constraints to IK fishing practices

Post-fishing activities

Materials used to process the fish

Tools used to store the fish in

What they do or add to preserve the fish

How they consume/prepare the fish

What other ingredients they add to the fish when preparing

Vegetation type

Substrate at fishing sites

Natural environment of the fish processing site

Animal types at fishing site

Sanitation of materials used for fishing activities

Fish species captured

Size of the fish captured (big, small)

What action the fishermen do when they capture small size fish

Any harmful practices to the resources

Any other significant observable activities

Appendix 4: An artificial identification key to fish species of Lake Zeway

Pair	Character/s		
1. a	Barbels present	2	
b	Barbels absent	4	
2. a	Scales present	3	
b	Scales absent		*Clarias gariepinus*
3. a	Dorsal fin with spines	6	
b	Dorsal fins without spines		*Cyprinus carpio*
4. a	Anal fin with 7 branched rays		*Carassius carassius*
b	Anal fin with more than7 branched rays	5	
5. a	Gill racker short, 18 to 28 on the lower part of anterior arch		*Oreochromis niloticus*
b	Gill rackers short, 8 to 11 on the lower part of anterior arch		*Coptodon zillii*
6. a	Lateral line scales greater than 46		*Labeoburbus ethiopicus*
b	Lateral line scales 20 to 44	7	
7. a	Maximum standard length 48.9 cm		*Labeoburbus intermedius*
b	Maximum standard length 10.5 cm		*Barbus paludinosus*

Appendix 5 Fish abundance data collection sheet during field survey

Fishing sites	Bekele Grisa				Abosa				Bashira Chefa				Bochesa				**Total**	
Season	Wet		Dry		Wet		Dry		Wet		Dry		Wet		Dry		**Wet**	**Dry**
Round	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2		
O. niloticus	56	49	30	11	60	37	19	9	34	35	26	8	12	30	51	52	**313**	**206**
C. zillii	7	4	15	6	8	8	12	12	7	5	7	4	3	5	2	3	**47**	**61**
C. carassius	11	19	13	8	8	17	14	14	10	12	8	13	8	8	13	21	**97**	**104**
C. carpio	18	26	14	15	17	13	28	22	19	26	21	36	18	30	13	19	**167**	**168**
B. paludinosus	5	5	7	8	8	3	6	8	6	6	4	4	4	8	6	9	**45**	**52**
L. intermedius	-	-	-	-	-	-	-	-	5	1	4	1	-	1	-	-	**7**	**5**
L. ethiopicus	-	-	-	-	-	-	-	-	4	-	4	1	-	-	-	-	**4**	**5**
C. gariepinus	2	8	5	3	2	3	11	13	2	3	5	4	2	3	8	9	**25**	**58**
Total	99	111	84	51	103	81	90	78	87	88	79	71	24	85	93	113	**701**	**659**
Overall	**210**		**135**		**184**		**168**		**175**		**150**		**132**		**206**		**1360**	