ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL &

COMPUTATIONAL SCIENCES

Fish Diversity, Abundance, Socioeconomic Importance and the Status of the Fisheries of Lake Hayq, South Wollo, Ethiopia

By: Zuriash Seid

A thesis submitted to Department of Zoological Sciences, Addis Ababa University, in partial fulfillment of the requirements for the Degree of Master of Science in General Biology

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Acronyms

DFID:	Department For International Development.
EWNRA:	Ethiopia Wetlands and Natural Resources Association.
EFASA:	The Ethiopian Fisheries and Aquatic Sciences Association.
FAO:	Food and Agriculture Organization.
FDRE:	Federal Democratic Republic of Ethiopia.
IBCR:	Institute of Biodiversity Conservation Research.
MARD:	Ministry of Agriculture and Rural Development.
MWIILEC:	Ministry of Water and Irrigation International Lake Environment Committee.
LFDP:	Lake Fisheries Development Project.
LLWRMP :	Logo Lake Watershed Rehabilitation and Management Project.
SFLP:	Sustainable Fisheries Livelihoods Program.

Abstract

This study was conducted on one of the northern high land fresh water lake; i.e., Lake Hayq, and its surrounding fishing community. The current fish diversity in Lake Hayq comprises of 4 species namely, Nile tilapia (*Oreochromis niloticus*), Catfish (*Clarias gariepinus*), Common carp (*Cyprinus carpio*) and Garra (*Garra dembecha*). However; *Garra* sp. has no economical value in the research area and hence it is not targeted & presented by fishermen. The fish species that is more abundant in the lake as a whole, around the lake shore and during dry (Begga) season is Nile tilapia, followed by common carp. Whereas, catfish is more abundant in the rainy season (Kiremt) in Lake Hayq. The species of tilapia and catfish are currently being depleted and not adequately captured. Instead, it is been identified that Carp (*C, carpio*), which has been introduced in to the lake in the recent years, reproduce very well and become dominated the lake. Sustainable fish resource in the lake provides animal protein and means of livelihood to surrounding community. However, it is found that the fish resource in the lake is facing biological and economical challenges. The current socio-economic importance of fish resources in the lake are stressed by demographic and economical pressures. Majority of the fishermen who were engaged in this fishing activities are young ranging from 21 to 30 years old. Individual fishermen daily fish catch exceed 100-200 immature tilapia per individual. Which estimated around 3513.6 quintal in a year. This indicated that in the current situation large number of tilapia (mostly preferred by surrounding community) harvested from Lake Hayq when we compared from past trends, but, low in quality (tilapia sp. become stunted). Due to this reason, individual fishermen monthly income did not exceed 1000 Et. Birr. Majority of them have no other income source for their livelihood and they are totally dependent on the lake's resources. Members of Logo Hayq-Ardibo fishermen association, on the other hand, found relatively in a better position as a result of their catching effort from Lake Ardibo in addition to Lake Hayq. The problem is aggravated due to little employment diversification opportunity and lack of government support or poor accountability. The major anthropogenic activities that aggravate fish resource destruction are overfishing practices of individual fishermen using non recommended gillnet with mesh size less than 8 cm and continuous fishing even during reproductive seasons of some fishes (eg. Nile tilapia). Moreover, environmental pollution, destruction of fish reproductive sites & water level reduction, further degraded the habitats of the fishes. Generally the absence of effective lake management system accelerated the decline of the fish resources in Lake Hayq. To overcome these adverse impacts on the fish resource, there should be continuous professional follow up, diversification of employment for youth, organization of individual fishers into fishermen association. Moreover, introduction of other systems of producing tilapia species (like aquaculture) to restock the lake is recommended. Furthermore, there is a need for further study about the cause of stunting tilapia in this lake during recent years.

Key words/phrases: Lake Hayq, diversity, abundance, socio-economic importance, lake management.

CHAPTER ONE: BACKGROUND

1.1. Fishery in Ethiopia

The Ethiopian economy is heavily dependent on the agricultural sector, which has suffered from recurrent droughts and extreme fluctuations of output (Demeke *et al*., 2004 cited in Lemma Abera *et al*., 2014). In addition, the country depends on inland waters for the supply of fish as a cheap source of animal protein. Ethiopia has a number of lakes and rivers with substantial quantity of fish stocks.

Ethiopia is uniquely rich and diverse in water resources. It has numerous water bodies including ponds, rivers, lakes, reservoirs and wetlands covering an estimated surface area of 18587 km^2 (Ethiopian Environmental Protection Authority, 2010 cited in Workiye Worie, 2009). Ethiopia is a landlocked country with only inland water bodies with suitable agro-ecology for fishing. According to the report of Ministry of Agriculture and Rural Development (MARD, 2004) from the total fish catch the share from the lakes is 85%, from rivers 6% and from dams and small water bodies is about 9% for the year 2000. Thus, the contribution of the lakes is very much significant. Moreover, it is this small-scale fishery sub-sector that provides the bulk of fish production and consumption (MARD, 2004 cited in Tarekegn Shado, 2006).

Based on the estimation of FAO (2001) the surface area of major lakes and reservoirs is 7,334 km^2 and the length of rivers is 7,185 km. Even though the diversity of the Ethiopian fish fauna is not fully researched, these water bodies give a refuge for more than 150 species in 29 families of which around 40 of them are endemic to Ethiopia (Abebe Getahun, 2007 cited in Workiye Worie, 2009, Assefa Tesema *et al*., 2013). This number has been increased to more than 180 currently (Redeat Habteselassie, 2012). The annual potential fish yield of the main lakes and rivers is estimated to be 51,481 tones and the total catches in 2001 were 15,389 tones which constitute 30 % of the potential yield (LFDP, 1995 cited in Workiye Worie, 2009). Annual fish consumption is also very low in Ethiopia (about 0.2 kg per person) compared to other African countries (FAO 2003); for example, Seychelles 47.5 kg, Sao Tome 37.6kg, Congo 33.4 kg (FAO, 2016).

Fisheries provide an alternative source of protein, micronutrients, minerals and essential fatty acids. It improves food security by providing an accessible and cheap protein source for the poor that supplement other locally available food sources (Thorpe *et al*., 2005; 2006; cited in Workiye Worie, 2009; Assefa Tesema *et al*., 2013). Nevertheless, the fishing sector has various problems. Among others, mismanagement of the resource, inappropriate policies and institution, inadequate technical and material back up to the sector and availability and accessibility to market are the major ones. Moreover, the Ethiopian lakes, on which the inland fishing is mainly practiced, are threatened by catchment's deforestation, shore damage, water pollution, siltation, eutrophication and over fishing (MARD, 2004, cited in Tarekegn Shado, 2006). The root causes of these phenomena are lack of integrated participatory wetland management of the area around the lake, population pressure and shortage of farmland in the nearby highlands, absence of other alternative livelihood diversification strategies to rural-urban migrants, and rural poverty and unemployment. Moreover, the policy and institutional gap in the management of common pool resources like fishery resource is a major factor in aggravating the resource depletion and exposing the small-scale fishing communities for food insecurity and unsustainable livelihood. According to FAO, 2001, rural poverty, food insecurity, malnutrition and under-nutrition are closely linked to the degradation of environment, as poverty depletes natural resource, which in turn aggravates the suffering of the rural poor. The interplay of natural resource degradation, poverty, food insecurity is so complex that one reinforces the other. The mainstream view is that poverty is a major cause of resource degradation (WCED, 1987; World Bank,1992, cited in Alemu Mekonnen, 2003).

The resource depletion and degradation become worse when it is an open access common pool resource with high demand. To alleviate the problem, the Federal Government of Ethiopia came up with a fisheries development and utilization proclamation in 2003, mainly covering utilization, access, and environmental aspects (proclamation no. 315/2003). However, although this legislation is in place, its enforcement is often lax and not applied in many Ethiopian lakes including Lake Hayq. Therefore, the practical measures taken to protect endangered fish species and declining fisheries have not been sufficient.

Factors that cause lake resource destruction

When surroundings of lakes are inhabited by local communities for centuries, there are strong interactions between local communities and lake ecosystems. In most cases, management plans that would ensure the conservation and sustainable use of lake resources are still lacking, or if it does exist, the plan is not well implemented. In addition, poor implementation of management plan drives lake users to put greater pressure on lake resources. Lake users are varied, and many have different interests and views on how to use lake resources. The major factors causing increased engagement in fisheries are the free access to the resource, high rate of unemployment, increased cost meeting basic needs, privatization of fish trade and increased products price, and higher earnings than certain other agricultural sectors (Bossche *et al*., 1991 cited in Tarekegn Shado, 2006). In spite of contribution of small-scale fisheries to the livelihood of considerable number of poor people in Ethiopia, the resource base of the lakes on which the lion share of fish production of the country depends is recently under threat.

Institute of Biodiversity Conservation and Research (IBCR) of Ethiopia has identified that weak institution for fish management and proper use, low awareness, discontinuity of research on wet land, and lack of alternative means of livelihoods, dependence of local communities on natural forest as source of energy, human and livestock pressure, and erratic rain fall as threats common to all lakes in Ethiopia (IBCR, 2000, cited in Tarekegn Shado, 2006). According to Lemma Abera (2011) anthropogenic climate change in Ethiopia is already affecting ecosystems and human societies that depend on them. Human impacts on wetlands include improper water utilization, destruction of lake side vegetation and improper lake resource utilization.

Improper water utilization

Overuse of the watershed together with climate change shift caused heavy erosion and silt accumulation in lakes and irrigation and power dams with the result that the water volume has been decreasing so fast. Lake Tana, Rift Valley lakes and Lake Haromaya are the most vulnerable water bodies to this phenomenon and as a matter of fact Lake Haromaya has already dried up. Due to reduced levels of precipitation and watershed

destruction, the volume of major rivers and perennial streams is decreasing. Small and large scale agricultural investors are engaged in irrigation based investments that consume large quantity of water. In addition to these they are using more intensive agricultural inputs specially pesticides, which may pollute the water body having long term effect on the aquatic biota. In addition to the above factors, pollution from infrastructures like road construction and urbanization are contributing factors in the case of Lake Hayq (Lemma Abera, 2011).

Destruction of shore line vegetation

Shore parts of wetland vegetations have great ecological importance, form buffers that help in water quality regulation, spawning grounds for many fish species, protect growing fish inhabiting the shore area from enemies and reduce disturbance and destruction by beach seine, it can supply fish feed by generating zooplankton and phytoplankton from the decomposing organic materials. However, some parts of wetland vegetation in some areas of Ethiopia are getting depleted due to over grazing, mowing for roof cover etc. The observed situation around Lake Hayq is one of the indicators about the worsening conditions of water bodies in Ethiopia (Lemma Abera, 2011) .

Improper wetland resource utilization

Fish production has become a victim of declining situation of wetlands. There are obvious damages of the breeding grounds of fish species that spawn in shallower parts of the water bodies. These effects are magnified in shallow water bodies where a higher rate of water level fluctuation has been observed (Zinabu Gebre Mariam,1998 cited in Lemma Abera, 2011).

Also, climate change can impact fisheries through multiple path-ways. Change in water temperature, precipitation and other variables, such as wind velocity, wave action and flooding can bring about significant ecological and biological changes to freshwater ecosystem functions. Some of the pathways identified in Allison *et al*., (2005 cited in Lemma Abera, 2011) are:

- Water temperature changes- shifting range of fish species, change in land water currents that affect upwelling zone fisheries and disruption to fish reproductive patterns and migratory routes.
- Precipitation and evapo-transpiration change on the hydrology of inland water: river flows and flood timing affecting fish reproduction, growth and mortality.

Fisheries Development and Management

The fishery industry has been of critical importance to the economy and to the social well being of communities. It provides a vital source of food, employment, recreation, trade and economic well being for people throughout the world. However, current harvest trends and fishery conditions put these attributes of the industry at risk. It is threatened with problems of overexploitation, environmental degradation and consequently unrecovered resources resulting in loss of its potentials (Abdurahman Kelil, 2002).

The importance of general discussion about fisheries development and management lies in the fact that the strategies which have been applied in marine environments have also been applied to inland fisheries (Laud and Neiland, 1997 cited in Desalegn Tadese,

2005). According to Laud and Neiland (1997 cited in Desalegn Tadese, 2005), through the 1960s-80s African governments put in place fisheries development policies which ought to increase production through the introduction of new technology; this was applied in both marine and inland fisheries. There has, however, been a general realization that the transfer of modern technology by itself has not been very effective and certainly not a sustainable way of alleviating poverty and guaranteeing food security (FAO 1984, Lawson, 1977 cited in Desalegn Tadese, 2005). New gear introduction without considering the local socio-economic conditions can have significant diverse effect. For example, in Brazil, the introduction of nylon nets to increase the output in order to supply urban areas caused tremendous disruption of the well-developed system of traditional property rights and community regulation.

The problem of overfishing may be better avoided by management measures taken along with development. Basic information like the relationships between sustainable catch and fishing effort, the biology of fish species, the nature and type of the fishery, the economic and social aspect and knowledge of environmental condition of the water body in which the resource is to be managed is necessary to have effective fishery management (Charles, 1998; Myers *et al*., 2001; Harwood and Stokes, 2003 cited in Zerihun Dejene, 2008).

The current social and economic conditions in Ethiopia, that is high population growth rates and low job opportunities coupled with the absence of an effective fisheries management, tend to lead rapidly to overfishing (Reyntjens *et al*., 1998 cited in Vijverberg *et al*., 2012).

To overcome the problem of common property nature of fisheries resources a number of management techniques are highlighted by Cycon (1986 cited in Dessalegn Tadese, 2005). In which the details of some are given below:-

Catch quotas: catch quota is an appealing concept. When the production reaches the quota the fishery is closed. This means that the total cumulated production must be known at any time. Clearly such a system requires the collection and processing of data in real time. In addition, the control system must be able to take action very fast. In

addition it has been under condition of environmental perturbation and retirement variation constant effort storage ultimately results in higher catch than a constant catch strategy. This is the case even when the two strategies correspond to the same theoretical reference point in terms of fishing effort Cycon (1986 cited in Dessalegn Tadese, 2005).

Closed area: a closed area is a fixed and known part of the water body that remains off limits for rounds (one after the other). There are different reasons a closed area may be desirable. The first is to protect certain life history stages. For instance, the nursery ground of some fish species with protracted or year round spawning seasons could be protected as closed areas. Alternatively, closed areas can be extremely useful to insure a minimum escape of the spawning fish. The second reason is that the part of a fish stock present in such closed area constitutes a buffer or reservoir protecting the fishery against fluctuations in yield. The major advantage of this tool is the relative ease of enforcement. There are no complicated rules in a closed area; any fishing activity is simply forbidden. The major problem with this tool is the difficulty in setting the size and precise location of the closed area. The bigger the closed area the more effective it is. However, fishermen communities are likely to want it to be as remote from their actual fishing grounds and landing point as possible. Cycon (1986 cited in Dessalegn Tadese, 2005). Closed area or "aquatic parks" are often recommended to preserve the biodiversity (example: Cichlids in the African great lakes). It is also known that some part of Lake Chamo has been closed for fishing for sometimes (Dessalegn Tadese, 2005). This tool is probably most adequate for lakes where same areas are not yet fished or little fished (example: Lake Hayq "Gedam Zone" side.

Closed season:- we speak of closed season when a part or the whole of a water body is closed for fishing during a specific time period each year. Seasonal closures are usually implemented to protect particularly vulnerable stages in the life cycle of a stock. Classical examples are migrating or spawning stocks and juvenile fish on the nursery grounds. To be effective such a tool requires that the specific moment and place a stock is vulnerable be clearly identified. The implementation of such a measure might, however, face strong opposition from the fishing dependent population as it, in effect, would remove one income generating occupation Cycon (1986 cited in Dessalegn Tadese, 2005). A typical

example is the case of Lake Tana in Ethiopia. The *Labeobarbus* spp. of Lake Tana migrate every year during the rainy season (July to October) to tributary rivers to spawn. They are faced with tremendous threat by fishermen who target the migratory species at the river mouth, where they aggregate or on their way to smaller tributaries. The regional government has issued a proclamation and directive to ban fishing during this time of spawning. However, it has become very difficult to implement it.

Mesh size regulations: in their most common form size regulations aim at allowing immature fishes to escape capture by gill nets. Mesh size regulations should be based upon knowledge of the reproductive biology of the stock and the selectivity of the gear considered Cycon (1986 cited in Dessalegn Tadese, 2005).This method may alleviate the declining tilapia species in Lake Hayq.

Limits on the number of boats (Tanqwa): fishermen need boats or some type of craft to go to the fishing grounds. Limiting the number of boats is a way of limiting the total effort Cycon (1986 cited in Dessalegn Tadese, 2005). However, this is only applicable when the boats or rafts used are relatively durable. In most cases the fishermen use bamboo rafts made either from bamboo or from a local soft wood. The fishermen themselves make theses rafts and replace them at intervals of a few months. Limiting the number of these bamboo rafts does not seem to be a realistic option which ever limit there will be on their numbers is more likely to come from the growing shortage of the construction materials, in particular the soft wood

Licensing: open access to the fishery is generally assumed to be the major problem in many lakes of Ethiopia including Lake Hayq. To overcome it, would require either a licensing system or some private or community rights. The major problems associated with a licensing system are the restriction of the number of licenses that would probably have to be decided by lake resource potential. Ideally, a license would authorize its bearer to fish with clearly specified types and numbers of rafts and gears. The Woreda office of agriculture has the right to issue licenses for a fee (Dessalegn Tadese, 2005).

Community rights: attributing community right to the fishery is only second on the auctioning of property rights as the easiest way for the authorities to get rid of the

problem of management altogether. The communities would get the responsibility of the management and giving emphasize to the necessity of fisheries management. Such communities would still need technical advice but would otherwise do as they like the major problem here is to identify the community to which rights could be given. In order to get the best possible supplies of fish for the future generation, it could be guaranteed when all those involved in fisheries work together to conserve and manage fish resources and habitats Cycon (1986 cited in Dessalegn Tadese, 2005).

Taxes on effort or catch: any form of taxation be it on the effort (such as the number of nets) or the catch, would make fisheries less attractive. If the taxes are reasonably well collected those efficient fishermen will be out of the business and reduce their overall effort in fishing activities. Therefore, taxation is able to correct the open-access fisheries as a means of regulating commercial fisheries Cycon (1986 cited in Dessalegn Tadese, 2005).

It appears that some of the management measures can be applicable in the case of Lake Hayq fishing community such as, mesh size regulation, closed area, community rights and closed season.

1.2. Statement of the problem

The contribution of fishery in some areas of Ethiopia such as Lake Hayq is very high in terms of supplying cheap sources of protein, employment, and covering house hold food security to the fishermen. Moreover, there is high number of people who are engaged in different fishing related activities such as local boat ("Thanqwa") making, fishnet making, fish product transporting, marketing, fish skin pealing and cooking (mainly females). Recently, however, as the fishery resource becomes depleted from Lake Hayq due to different reasons the sustainability of the resource as well as the sustainability of the fishermen's livelihood are affected. Demographic and socio-economic changes affect the existence and long–term sustainability of the common pool fishery resource of Lake Hayq. The increase in population, high demand of fish products, lack of alternative income strategies and high unemployment rate have put serious stress on the fish

resource of Lake Hayq. This condition may have been caused by inappropriate lake management system, that aggravate overfishing and using illegal fishnet by illegal fishermen, introducing pollutant agents, destruction of reproductive sites of fishes and reduction of lake depth by sedimentation from highly expanding farming lands. Drought in the area is one of the causes that led to the destruction of the habitats, particularly the lake ecology affecting the economy of the fishing community. It is believed that fishery resource degradation and associated impacts on Lake Hayq are least researched on, getting little attention by responsible local government sectors and there is lack of awareness by local community about the impacts of their practices on the lake resources. The integration or collaboration of responsible partners will help to alleviate the resource destruction and can improve on the sustainability of resources for fishing communities.

1.3. Research questions

1. What is the trend of the fish diversity and abundance in Lake Hayq through time?
2. What are the socio-economic importance of fishes in Lake Hayq to the surrounding communities?
3. Does inefficient Lake management system affect the lake resources?
4. What factors did cause fish decline in Lake Hayq?
5. Are there possible measures that can be taken to keep the Lake Hayq's fish resource utilization sustainable?

1.4. Objectives of the study

General objective

The general objective of this research is to assess the current status of the fish and fisheries of Lake Hayq and suggest appropriate measures to conserve the fish resource.

Specific objectives

1. To assess the current diversity and abundance of fishes in Lake Hayq.
2. To assess socio-economic importance of fishes in the surrounding communities.
3. To assess the contribution of concerned Government sectors in Lake Hayq management systems.
4. To assess lake resource utilization trends of the community and its impact on the fish resources of Lake Hayq.

1.5. Significance of the Study

Lake resource like other natural resources must get attention to ensure the sustainability of the resources and to satisfy community demands. The majority of researches done in relation to natural resources in Ethiopia are mainly focused on other resources such as soil and water conservation, forest conservation, hydro electric power production and wild life conservation, and little attention was given to lake resource conservation. Based on these problems this study is initiated to analyze the present situation of the lake and come-up with updated information that would help managers to further investigate and manage the lake fisheries. It is hoped that, this research will have its own contribution in creating awareness in the surrounding community about wise use of lake resources in order to minimize their inappropriate fishing practices that is leading to lake resource loss. Based on the research findings, it is expected to indicate the value of the community involvement in the resource conservation, and importance of getting attention by

government sectors. It could also suggest the importance of continuous follow up, improving community awareness about lake resource conservation, particularly to the fishing community, controlling and monitoring effort and in the publicizing of Federal and regional fisheries management proclamation to fishermen. Moreover, to indicate the need of further research to identify the cause of size reduction in tilapia sp. in order to ensure Lake Hayq resource sustainability to the next generation.

CHAPTER TWO: MATERIALS AND METHODS

2.1. Description of the study area

2.1.1. Physical Features

Lake Hayq (also called Loggo) is a freshwater lake and located in northern Ethiopia, Amhara Regional State, South Wollo Administrative Zone 433 km far from Addis Ababa the capital of Ethiopia. Lake Hayq is one of the highland lakes of Ethiopia at an altitude of 2,030 m. (Fig 1.). The lake lies between latitude of 11^0 15 'N and a longitude of 39^0 57' E (Baxter, 1970).

Figure 1 . An over view of Lake Hayq, the study site.

The surface area, mean and maximum depth of the lake is 23 km^2, 37 m and 88.2 m, respectively and has a volume of 0.87 km^3 (Baxter, 1970). According to a local legend,

the lake was created to avenge a pregnant woman who was wronged by a princess. God was greatly angered by this injustice, and in his wrath turned all of the land surrounding the woman (except the ground she was sitting on) in to water forming a lake, destroying the princess along with her friends and family in the process. Where the pregnant woman was sitting became an island (now a peninsula) where Estifanos Monastery was, founded in the middle of the 13th century by Iyesus Mo'a. The first known European to view the lake was Francisco Alvares, who passed near it on 21 September 1520; he mentioned that the lake had Hippopotamuses and catfish, and the land around it were planted in lemons, oranges and citrons (Wikipedia, 2015). The legend about the creation of Lake Hayq is also supported by local elders, but there is no record of Hippopotamus in the lake for the last several years. The island near the west shore, on which the monastery is located, was attached to the shore by a low isthmus, covered with vegetation. One of the local elders, Ato Ali Seid, indicated that around 30 years before the isthmus that connect the Istifanos Monastery to main land was covered with lake water due to high water level of Lake Hayq. This indicated that the previous Lake Hayq water level situation was very high when we compare it with the current situation.

However, its water level fluctuates since 1970 due to anthropogenic influences (abstraction and input from irrigation return flow). It receives water from many small seasonal streams and one perennial river, Ankerka, but has no surface outlet and its freshness has been attributed to a possible subsurface out flow towards the west through East-West fractures (Molla Demlie *et al*. 2007 cited in Dagnachew Melaku and Abate Shiferaw, 2014). The catchment area of the lake is 65 km^2 and it is located in northern highlands and the western margin of Afar triangle. The lake has a closed drainage system within the water shade of the Awash River basin (Molla Demlie *et al*., 2007 cited in Dagnachew Melaku and Abate Shiferaw, 2014).

Bathymetric studies of Lake Hayq indicated the lake has experienced depth and surface area changes. Baxter and Golobitsch (1970) observed that the water level of Lake Hayq was appreciably lower at the same time of their visit in January 1969 than in May 1938. A maximum depth of 88.20 and 81.44 m, and surface area of 2302.02 and 2245.65 ha were recorded in 1941and 2013, respectively (Baxter & Golobitsh 1970;Yesuf *et*

al.,2013). Other studies (Dagnachew Melaku and Abate Shiferaw, 2014) also indicated gradual decrement of water level in Lake Hayq. This may cause total drying of the lake sometime in the future. Since the 1970s, the water level problem in Lake Hayq was clearly observed and the island was completely changed to peninsula and connected with the great landmass at the western edge of the lake through the narrow strip of land or isthmus. The rate of water reduction has been increasing through time. For example, the lake decreased by 472 hectares in four hundred years, where as in the past 30 years the lake decreased by 108 hectares. Based on the previous lake shape, and area model; now, the lake level lowered with 22 meter and almost 5.8 km^2 or 580 hectares surface area of the lake were shattered (Dagnachew Melaku and Abate Shiferaw, 2014). It was also reflected in the present study discussion with local elders, in which they said that the amount of water level in the lake is decreasing gradually.

Lake Hayq provides a habitat to different fish species, water birds and aquatic organisms. It also plays an economical role via tourism and fishery, and most importantly it provides drinking water to the local inhabitants (Tadesse Fetahi *et al*., 2011). But the water level fluctuations are known to contribute to the loss of great diversity of ecology and socio economic development. These environmental challenges might likely damage the fish fauna, phytoplankton, zooplankton and other species as well as the lake ecosystem (Workiye Worie, 2009). Seyoum Mengistou (2006 cited in Workiye Worie, 2009) reported that the major threats facing Lake Hayq are overfishing, pollution, catchment degradation, encroachment and water withdrawal. Moreover, rainfall variability, population pressure, land misuse, and resource competition resulted in catchment degradation of the lake.

These environmental challenges might likely damage the fish fauna, phytoplankton, zooplankton and other species as well as the lake ecosystem. For example, studies have shown that there was mass fish kill due to eutrophication in 1992 (Elizabeth Kebede *et al*., 1992).

There is also one big monastery (Haik Estifanos) which serves as a holly site for Orthodox Christian pilgrims. Moreover, it is one of the tourist sites for eastern part of Amhara region (Fig. 2).

Figure 2. Front view of Estifanos Monastery**.**

2.2. Methods

In order to achieve the objectives of the study and for the sake of gathering data concerning the current status of the fish and fisheries of Lake Hayq; field observation, structured questionnaire, key informant interview & focus group discussion were used by means of adapting & adopting.

Primary data- primary data was collected through:

- **Field Observation:** used to observe the fish diversity and abundance of fish species, fishing practices of fishermen in the lake, the situation of lake shore line including expanding farm lands and urbanization, as well as marketing site of fishes.
- **Questionnaires:** data were collected from individual fishermen, members of Logo Hayq–Ardibo Fishermen Association, as well as Hotels and Restaurants. The current abundance of fish species in Lake Hayq, socio-economic importance of fishery, fishery management trends and suggested possible measures was determined by collecting data from target groups through constructed questionnaire.
- **Interview:** with representatives of Logo Hayq-Ardibo Fishermen Association, Zone and Woreda's Agriculture and Rural Development Natural resource and fishery experts, who have knowledge about fishery and fishing communities in the research area. Current and previous trends of physical and biological status of research area, fishery trends and lake resource management systems were determined through interview in addition to using questionnaires.
- **Key informant discussion:** is another method to collect information about past and current fishery trends. The discussion took place with local elders, young individual fishermen, and with representative of Worebabo Woreda 02 Kebele (East border of Lake Hayq) farmers Administration office, who have experience in the topic.
- **Secondary source:**

  The secondary data were collected from the Zonal, Woreda Agricultural and Rural Development fishery experts, culture and tourism bureau and other related offices. Moreover, documented information related to the study was reviewed. Books, Brochures, Research reports, published and unpublished, and survey written documents were assessed from the different Government offices of the Woreda. Internet web sites were assessed to collect related information about the research area.

2.3. Population and sample selection

The estimated population of fishermen before five years were about 535. However, in the recent discussion with Woreda Agriculture and Rural Development Fishery experts, local elders and from researcher's own observation the number of fishermen estimated may be less than 535 (exactly unknown). Probably, due to the declining fish resources of Lake Hayq, the numbers of fishermen who are engaged in the fishing activity are supposed to be reduced to 400. From among these fishermen, 102 of them were randomly selected from Haik town, Fishermen were also identified from Tehuledere Woreda Lake Hayq surrounding rural kebeles). There is one fishermen cooperative called Loggo Hayq–Ardibo Fishermen Association, (organized by 65 rural and 10 urban based members) 25 fishermen were randomly selected from the 75 members of this association. The above sample includes both urban and rural fishery communities and full time and part-time fishermen. The third focus group discussion was with hotel restaurant owners in Dessie and Haik Towns, who use fishes from Lake Hayq to prepare fish meals for their customers. Eight from Haik and six from Dessie were randomly selected.

2.4. Data Analyses

Both qualitative and numerical data analysis techniques were employed by correlating the data obtained from three focus groups (Individual fishermen, Members of Logo Hayq–Ardibo Fishermen association and Hotels & Restaurants) with key informants. Data obtained from the primary sources were tabulated, analyzed and interpreted similarly. The information obtained from focus group discussion and field observation was described mostly in a qualitative manner. Data such as the trend and temporal variation of fishermen, fishing technology, fish catch, mesh size, fish price, monthly income were also analyzed in a quantitative manner.

CHAPTER THREE: RESULTS AND DISCUSSIONS

3.1. Fish Diversity and Abundance

Fish diversity: The fish diversity of this research area were identified mainly through direct observation during field work. The fish diversity known in Lake Hayq consists of only 4 species, Tilapia (*Oreochromis niloticus*) locally called "Kerosso", Catfish (*Clarias gariepinus*) locally called "Ambaza", Common carp (*Cyprinus carpio*) locally called "Dubae", and Garra (*Garra dembecha*) locally called "Yewenz Assa" meaning river fish (Fig. 3).

A. Tilapia (*Oreochromis niloticus)*

B. Carp (*Cyprinus carpio)*

C. Catfish (*Clarias gariepinus*)

D. Garra (*Garra dembecha*).

Figure 3. Fish diversity in Lake Hayq, A. Tilapia, B. Carp, C. Catfish & D. Garra sp

However, only three species are used for food by the local communities (Tilapia, Catfish and Carp). *Garra dembecha* is having no economical value in the area and not targeted by fishers for sale. Sometimes the fishermen used this small sized fishes as bait to catch Catfish by hooks and lines.

This research finding on the fish diversity of Lake Hayq is in line with previous reports (Elizabeth Kebede *et al*., 1992, Abebe Getahun and Stiassny, 1998).

Fish abundance: the abundance of fish species in Lake Hayq was estimated based on data collected from fishermen responses' and through field observation at fish landing sites. The fish abundance in Lake Hayq, as a whole, in the lake shore, during rainy season (Kiremt) and dry season (Begga) is provided (Tables 1 and2).

Table 1. Individual Fishermen's responses on abundance of fish species.

Abundance of fish species	**Tilapia**		**African cat fish**		**Common Carp**		***Garra* sp.**		**Total**	
	No. of respondents	**%**	**No. of respondents**	**%**	**No. of respondents**	**%**	**No. of respondents**	**%**	**No. of respondents**	**%**
Whole lake	58	56.9	10	9.8	34	33.3	0	0	102	100
Shore areas	60	58.8	7	6.86	33	32.3	2	1.96	102	100
During Kiremt	11	10.7	67	65.7	20	19.6	4	3.92	102	100
During Begga	78	76.4	2	1.96	22	21.5	0	0	102	100

Table 2. Responses from members of Logo Hayq-Ardibo fishermen association on abundance of fish species

Fish abundance	Tilapia		African cat fish		Common Carp		*Garra* sp.			%
	No. of respondents	%	No. of respondents	%	No. of respondents	%	No. of respondent	%	total No. of respondents	
Whole Lake	21	84	0	0	4	16	0	0	25	100
Shore areas	20	80	0	0	5	20	0	0	25	100
During Kiremt	9	36	16	64	0	0	0	0	25	100
During Begga	20	80	3	12	2	8	0	0	25	100

According to their target fish, most of the individual fishermen (56.9%) revealed that, in the current situation, the fish species more abundant in the lake as a whole is tilapia, while some (33.3%) consider carp as the most abundant and few (9.8%) fishers still think that catfish is the most abundant.

Similarly, the majority (84%) of members of the association responded that**,** the fish species currently abundant in the lake is tilapia and few (16%) of fishers indicated that common carp is the most abundant in the lake as a whole.

Based on the result obtained from the two groups, the fish species more abundant in the lake as a whole is tilapia (*O. niloticus*).

It has come also evident that most fishermen (58.8%) believe that tilapia is the fish species most abundant around the shores followed by carp (32.3%) and then catfish (6.86 %) and *Garra* sp (1.96%).

The results have also suggested that most individual fishermen (65.7%) consider that catfish is more abundant in the lake during kiremt while some (19.6%) claim that carp

may be more abundant. Few (10.7%) have suggested that tilapia may be the dominant during kiremt while very few (3.92%) regard *Garra* spp. to be dominant. Similar result was also obtained from members of fisher's association and it appears, thus, that the most abundant fish species during the dry season (kiremt) is African catfish (*Clarias gariepinus*).

On the other hand, most individual fisher respondents (76.4 %) think that tilapia is the most abundant fish species in dry season, whereas some (21.5%) and few (1.96%) consider carps and catfish, respectively to be the most dominant. This was also confirmed by members of the cooperative.

In general, based on the responses obtained from individual fishers and members of the association it is tilapia which is the most dominant fish species in Lake Hayq as a whole, around the lake shore and during dry season, whereas, catfish seems to be the most abundant in the rainy season in Lake Hayq.

The dominance of *O. niloticus* 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). Before stocking of Nile tilapia into the lake, the most available fish was probably the African catfish. However, it appears that there is a trend of reduction in the population of tilapia in the lake.

All (100%) respondents from the 3 focus groups (individual fishers, members of the association, Hotels & Restaurants) indicated that the species of tilapia and catfish are currently being depleted and not adequately captured and presented to consumers. Instead, it has been identified that Carp (*C. carpio*), which has been introduced into the lake accidentally through Ankerka river in the recent years, reproduces very well and dominated the lake. It has also been found that the carp in Lake Hayq is with a good flavor and size better than the ones from Lake Ardibo, its previous habitat.

3.2. Socio-economic status

3.2.1. Demographic and social characteristics of participants

The demographic information and social characteristics of fishermen who participated in this research work is provided in Table 3.

Table 3. Demographic Information of the Research Participants

Aspects (Dimensions)	Description	Number 0f Individual Fishers	Number of Members of the Association	Sum	
				Total	%
Sex	Male	102	25	127	100
	Female	0	0	0	0
	Total	102	25	127	100
Age	14-20	27	0	27	21.3
	21-30	54	6	60	47.2
	31-40	20	17	37	29.1
	41-50	1	2	3	2.4
	> 50	0	0	0	0
Formal Educational Level	0	6	0	6	4.7
	1-4	15	2	17	13.4
	5-8	17	12	29	22.8
	9-10	37	11	48	37.8
	11-12	12	0	12	9.4
	Diploma	11	0	11	8.7
	First Degree	4	0	4	3.1

This result showed that, there is no female participant, the majority of fishermen in the association were above 30 years of age and the minimum and maximum age of individual fishermen were 16 and 42, whereas, the age ranges for members of the cooperatives were from 21 to 50. This is indicative that it is the younger ones who are largely practicing inappropriate fishing. The educational status of few individual fishermen extended up to first degree and many (36.2%) of them completed grade 10, and not transferred to the next grade level or may not have gotten the chance to extend their study. This low level of education might have contributed for their resource to fishing activity.

Fishing experience of respondents: The fishing experience of participants was determined by fishermen's response in the questionnaire, and it is given in Table 4.

Table 4. Fishing experience of fishermen

Fishing experience in years	**Individual fishers**		**Members of Logo Hayq-Ardibo fishermen association**	
	No. of respondents	**%**	**No. of respondents**	**%**
1-5	34	33.3	1	4
6-10	27	26.4	4	16
11-15	23	22.3	13	52
16-20	12	11.7	6	24
21-30	4	3.92	1	4
>30	2	1.9	0	0
Total	102	100	25	100

Most of individual fishermen (59.7%) have fishing experience less than 10 years, whereas, the majority (80%) of members of Logo Hayq-Ardibo fishermen's association had experiences of above 10 years. Fishing experiences of most respondents began by learning from their father's or elder brother's fishing activities in their locality, first for

home consumption and as a means of earning pocket money, and later they were engaged fully or as part-time fishers. Many of the young fishermen are children of the older fishermen and inheriting their parents' job. For example, discussion with one key informant, (local elder and a former fisherman) indicated that, his all sons followed his fishery practices to support their family's needs. Others began fishing as a means of income to support their household due to its common property nature and lack of other alternative employment.

3.2.2. Fishing boats and Fishing gears

Fishing boat There are 18 boats (6 motorized and 12 non-motorized) operating in Lake Hayq. Motorized and non-Motorized boats are made of steel or fiber glass and are mainly used for rental purposes for recreation and researchers. Sometimes few fishermen used non- motorized boat to transport captured fishes from the lake to shore fish landing sites, However, members of Logo Hayq- Ardibo fishermen's association have recently shifted from Lake Hayq to Lake Ardibo and they use their own 7 (one Motorized and 6 non Motorized) fiber glass boats for the purpose of fishing. Individual fishers in Lake Hayq mainly use local Raft made of bamboo called "Thanqwa" (Fig. 4) to set their nets into the lake and to transport fishes to fish landing site. More than 400 raft and gillnet were used by individual fishers to catch fishes in the previous years (communication with key informants). However, the current situation appears to indicate sign of reduction in the number of raft and fishnets because of the fish resource reduction in the lake.

Figure 4. Fisherman landing his collected fishes using raft and gillnet.

Fishing gears: Fishermen use fishing gears such as gill nets mainly to target tilapia, long lines with hooks targeting carps and catfish and occasionally they use spears to target catfish from the lake shore. The majority (95%) of fishermen used gillnet mesh size less than 8 cm and catch small sized fishes (Figure 5). Almost half of individual fishermen (about 200) make their own fishnet from plastic strings (Figure 6)

Figure 5. Nets of mesh sizes of less than 8 cm.

Figure 6. Fishermen during gillnet making activity

3.2.3. Current and previous fish production trends

Current fish production status

Fish catch: The amount of fish harvested by each individual per day vary, which depends on individual effort, gear quality, availability of target species in the lake (tilapia, carps or catfish), and season. The number of tilapia and carps captured per day by each fisher (Table 5) represent the current trend.

Table 5. The amount of fish caught by fishermen per day

The number of fishes (tilapia & carps) captured by each fisher per day.	**Individual fishers**		**Members of the Association**	
	No. of respondents	**%**	**No. of respondents**	**%**
15-50	15	14.7	0	0
60	6	5.8	1	4
70	4	3.9	2	8
80	8	7.8	5	20
90	0	0	4	16
100-150	45	44.1	13	52
200 and above	24	23.5	0	0
Total	102	100	25	100

Most (67.6%) of the individual fishers captured about 100-200 immature tilapia species per day, which is indicative of the overfishing practice of illegal fishers particularly on tilapia. Members of the association mainly target large sized tilapia and carp, and hence the number of fish caught per day ranges from 60 (minimum) up to 100 (maximum) with average 90.4 fishes per day (Table 5). It has been found that the amount of fish caught per day for individual (non-organized) fisherman was ranging from 50-200 for tilapia with average of 122.1 fishes per day, and for carps ranging from 15-30 per day.

The response of individual fishermen has indicated that large number of fishes were harvested, but, low in quality (small in size). Also, the majority of fishermen from the association couldn't harvest sufficient amount of fishes from Lake Hayq, and that was why they had to exert more effort on Lake Ardibo to get more fishes to support their livelihood. All (100%) of the respondents indicated that the fish catch they obtained from Lake Hayq in terms of quantity as well as quality couldn't satisfy their customers.

Past fish yield trends: Data on the past trends of fish catch for the period 1993-2012 have been obtained from Tehuledere Woreda's Agricultural office (Table 6).

Table 6. Fish yield trends of Lake Hayq in quintals, estimated (from 1985-2004 EC) (1993-2012).

Year (E.C)	Fish yield from Lake Hayq in quintals
1985	392
1986	879
1987	1328
1988	2796
1989	386
1990	2520
1991	2294
1992	2532
1993	2637
1994	2740
1995	2560
1996	2800
1997	2600
1998	2400
1999	2394
2000	2508
2001	2503
2002	2526
2003	2727
2004	2500

Source: Tehuledere Woreda Agriculture and Rural Development Bureau. (Fishery expert studies, 2005, unpublished data).

The above result (Table 6) about past fishing trend in Lake Hayq indicated an average catch of about 2201.1 quintals per year. According to local elders discussion, the past fish yield could satisfy demands of the local communities at that time, because tilapia and catfish were abundant with better size in Lake Hayq. But now these two species show declining trend due to highly extended fishing pressure on the lake. Therefore, the trend of production in the last 20 years is a trend of increase in production, probably beyond the maximum sustainable yield of the fisheries resources (392 quintal in 1985 increased up to 2800 quintal in the year 1996 EC). This trend is indicative that there is overfishing practices in this lake.

This decline in fish population, particularly in tilapia is not only in number but also in size reduction in which they have become stunted. 100% of the respondents affirm that *O. niloticus* is relatively abundant in Lake Ardibo than in Lake Hayq in the current situation.

The present situation may be even worse than reported in Table 6. One could compare the present situation with the past trends by taking the catch by individual fishermen per day which is about an average of 122.1 tilapia per day by each fisherman (Table 5), which is estimated around 4.8 kg/day, (if 25 small sized tilapia is equivalent to 1kg.). So 122.1 fishes=4.8 kg.

- If about 200 fishermen are engaged in a day,
- 4.8 kg x 200 =979 kg = 9.76 quintal of fishes would be harvested in each day.
- 9.76 qux30days= 292.8 quintals of fishes will be harvested per month. This will be an estimated amount of 3513.6 quintals per year, which is well beyond what have been produced in the last 20 years (a maximum of 2800 quintals recorded in 1996 EC) (Table 6).

From the above estimation, one can see the overfishing trends in Lake Hayq. If this current overfishing trends continue, the fish resource in Lake Hayq can be endangered or may totally be lost.

As it is generally known, lakes are threatened with problems of overexploitation, environmental degradation and consequently unrecovered resources resulting in loss of their potentials. These resources, although renewable, are not infinite and need to be properly managed, if their contribution to the nutritional, economic and social well-being of the growing world's population is to be sustained FAO (1995 cited in Abdurahman kelil,2002). Also, William and Johannes (1998 cited in Abdurahman kelil, 2002) pointed out that there is a worldwide consensus that fisheries need better management if they are to continue making a major contribution to the economy and social well being of society.

3.2.4. Fish Marketing

The fishermen present the fishes to the market in different forms depending on the choice of customers and the type of fishes captured by fishermen. Tilapia, most of the time, is presented in fillet form, and catfish and carps are usually presented in whole. Fishermen's responses on the fish forms presented to the market from Lake Hayq is given in Table 7.

Table 7. The fish forms presented by fishermen to the market

Fish's form	**Individual fishers**		**Members of Logo Hayq-Ardibo fishermen association**	
	No. of respondents	**%**	**No. of respondents**	**%**
Whole fish	29	28.43	1	4
Processed - Fillet	43	42.15	24	96
Presented both as whole fish & fillet form	30	29.41	0	0
Total	102	100	25	100

Many of the individual fishers present their fishes in the form of fillets (Fig. 7) while some of them sell it as whole fish and some others respondents present both as whole fish and also

in the form of fillet. Whereas, almost all members of the association (96%) present fishes in the form of fillets. The above data indicate that fishes in fillet form are preferred in the community.

Figure 7. Fillet fish from fisherman for sale in Haik Town.

Fishermen sell collected fish to different customers, such as, individuals, hotels and restaurants or traders (Figures 8. and 9).

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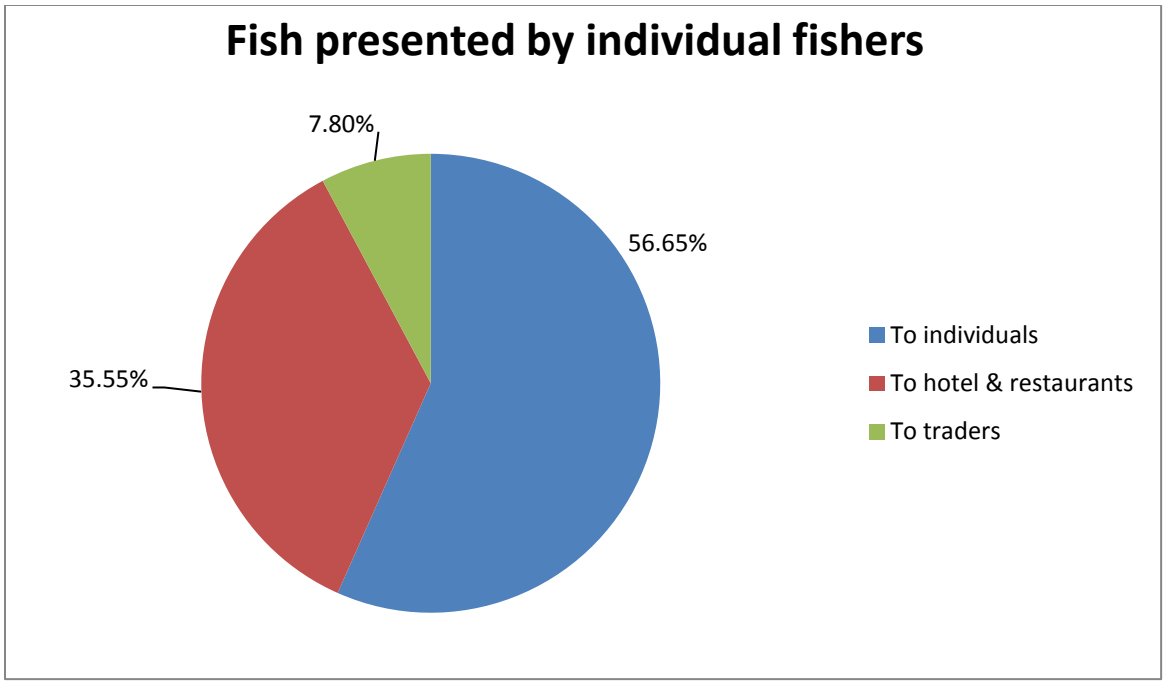

Figure 8. Market outlets for individual fishermen.

Most (56.65%) of individual fishers sell their fishes to individuals, few (7.8%) to traders and they have little chain with traders.

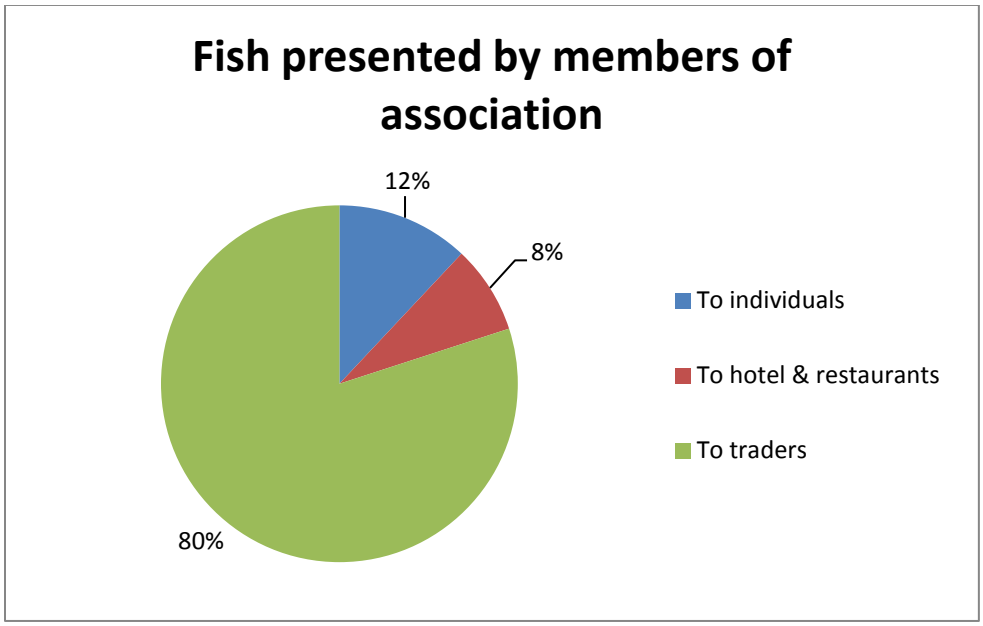

Figure 9. Market outlets for members of the association.

The market chain for fishermen of Logo Hayq-Ardibo fishermen's association (Fig. 9) is different from that of the individual fishers (Fig. 8), because the majority of organized

fishers (80%) sell their fishes directly to traders at the fish landing sites, and only few (20%) sell their products to consumers, hotels and restaurants.

Members of the association could collect fishes better than individual fishers in terms of quality and quantity due to the fish net mesh size being greater than that of the individual fishers, and their harvesting activities being from both lakes. Moreover, members of the association got a better chance to supply their fish without transporting long distances. Whereas, individual fishers operate and present their fish product to the market in a non-organized manner.

The fish produced from Lake Hayq was marketed at Haik, Bestema, Dessie, Kombolcha, Woldia, Debreberhan and Addis Ababa. Schoolboys at the town of Haik are involved in fishing activity to overcome their school expenses. Women are mainly involved in processing and cooking. Most hotels in Haik town are known for their fish dish. Respondents from hotels and restaurants in Dessie and Haik Towns, showed that the three species of fishes (Tilapia, Catfish and Carps) are preferred for consumption in their order. The fish meal types prepared by the hotels and restaurants for their customers are, half cooked or underdone fish (Assa Lebleb or Dulet), Cotelette, Fried fish, Goulash, “Assa Wet,” “Gored Gored”, “Kurte” “Mahberawi”. The fish dishes that are more preferred by the majority of customers are, half cooked or “Assa Lebleb” (Fig. 10). Fried fish and fish slice or “Gored Gored” are the second and the third choices of the consumers, respectively.

Figure 10. " Assa Lebleb", one of fish meals prepared from Tilapia at Logo Haik Lodge.

According to most of individual fishers (57.8%) and 92% of members of the association as well as discussion with local elders, the fish species that is more preferred for consumption by the surrounding community is tilapia, due to its good flavor, and African catfish is the second favored type. Fish supply and fish demand in the locality are not balanced. Based on the result obtained from hotels & restaurants 57.14% of the respondents from Haik Town are still getting fish from Lake Hayq and Ardibo, whereas, all participants from Dessie Town obtain fishes from other water bodies such as Tana, Ziway, Hawasa, Tekeze and Ardibo to satisfy their customers. In order to alleviate fish supply reduction from Lake Hayq, fish traders bring and distribute fishes from different lakes to hotels and restaurants of Kombolcha and Dessie Towns.

Fish price: Fish price in the research area is based on fish size but not weight and the prices vary depending on the species, the form (whole fish or fillet). The price also fluctuates during Orthodox fasting and non-fasting seasons, showing increase during fasting and decrease in non-fasting period. Based on the survey result from individual fishermen respondents, the average fish price for tilapia fillet is 1.00 Eth. Birr. because of its very small size, where as the whole part of one carp depending on the size, may cost from 30 to 40 Eth. Birr. Members of Logo Hayq-Ardibo fishermen association respondents estimated the price to be in the range of Eth. Birr 50.00 (minimum) up to 90.00 (maximum), with the average of 76.2 Eth. Birr per kilogram for tilapia (catfish and carps determined by each fish size, not on kilogram). However, this price may be higher when it is presented directly to the traders.

Monthly income of fishermen:

Monthly income of fishermen was determined by their responses for the questionnaire. Monthly income for both groups is given in Table 8.

Table 8 . Fisher's income per month

Fishers monthly income in Eth. Birr.	**Individual fishers**		**Members of Logo Hayq-Ardibo fishermen association**	
	No. of respondents	**%**	**No. of respondents**	**%**
< 750	6	5.9	0	0
750-1000	63	61.76	0	0
1100-1500	16	15.68	0	0
1600-2000	9	8.82	0	0
More than 2000	8	7.84	25	100
Total	102	100	25	100

Monthly income of the majority of individual fishermen (67.4%) did not exceed 1000 Eth. Birr. This is because, most of the times they capture small sized tilapia due to low fish availability, and they must stay the whole day to get few fishes. Due to low income they get from fishing, about (47.05%) do not have private house to live in and they are dependent on their families and relatives. Because the majority of individual fishermen (72.6%) have no any other means of income to support their house hold, they are fulltime fishers.

The situation is very challenging and there is considerable hardship to cover their household demand, and hence the pressure on the lake resource has been increasing from time to time. Few individual fishers (27.4%) support their income by practicing farming, animal breeding, small trading and government employment in addition to fishing and they are part- time fishers.

Members of Logo Hayq-Ardibo fishermen association, on the other hand, as shown in Table 8, are found relatively in a better position. All (100%) respondents' monthly income is more than 2000.00 Eth. Birr per head. They are benefiting as a result of their catching effort from Lake Ardibo in addition to Lake Hayq. Lake Ardibo is under the control of this association, and relatively protected from individual fishers. As a result, members of the association could collect fishes better than individual fishers in terms of quality and quantity since the former use nets with mesh size greater than the individual fishers. They also use better fishing technology such as refrigerator as a means of preservation, motorized and non motorized boats to catch and transport fishes, and they have better chance to supply their fish without transporting long distances. The majority of respondents (92%) have their own private house, and only few (8 %) respondents are living with their families. They had also common capital in the association.

There are complaints as to why the individual fishers cannot be members of Logo Hayq-Ardibo fishermen association. The reasons include the considerable distance from Lake Hayq to Lake Ardibo, the high registration fee (1000 Eth. Birr), absence of support from government sectors to organize individual fishermen, and little awareness about the benefits from fishermen association.

3.3. Support from government sectors

The presence of government support for the fishery sector and lake management system in the research area were determined by data collected from fishermen, Zone and Woreda Agricultural and Rural Development Bureau and local elders, using questionnaire and interview.

The majority 77 (75.4%) of individual fishermen and all (100%) members of the association, revealed that there is no support or training from professionals or the relevant government body about how to use fish resource in an appropriate way; only 18 (17.64%) individual fishers have received training and 7 (6.8%) of them were not sure. This result shows that the government sector in the research area does not give attention for this sector.

The majority of respondents (90.12%) replied that they didn't have information about the proclamation (No. 315/2003), that stated about fishery management and utilization; only 8 (7.8%) respondents have awareness about this proclamation, and the rest 2 (1.98%) are not sure.

Discussion with key informants particularly with South Wollo Agriculture and Rural Development Bureau, Natural resource department, animal husbandry experts, on the other hand, indicated that they have given training to members of the fisher community, and representatives of the surrounding farmers about wise use of lake resources and shore line land management system. However, they admit that it was not sufficient and effective, because there is no regulation to take measures on illegal fishers. Moreover, there is wrong perception about communal nature of lake resources and there is acute shortage of budget and financial support on the part of the government for appropriate follow ups by experts.

This study, thus, identified that there is no effective lake resource management system or low contributions in the conservation of lake resources from government sectors, fisher communities and Lake Hayq surrounding communities.

FAO (1999 cited in Felegeselam Yohannes, 2003) stated that the best possible supplies of fish for the future generation could be guaranteed when all those involved in fisheries work together to conserve and manage fish resources and habitats. Giving emphasis to the necessity of fisheries management, countries to manage their fisheries need to have clear and well-organized fishing policies which are developed in cooperation with all groups that have interest in fisheries (FAO, 1999 cited in Felegeselam Yohannes, 2003).

3.4. Factors that cause fish resource depletion in Lake Hayq

3.4.1. Fishers overfishing trends on the lake resource:

Major adverse problems in fishing practices or overfishing trends of fishers include, but not limited to, application of inappropriate fishing gears and fishing during reproductive seasons and fishers' awareness about the wise use of fisheries resources. Fishers response (Yes or No) about their trends in the application of inappropriate fishing practice are shown in Tables 9 & 10.

Table 9. Responses of individual fishers on fishing gear used and time of fishing.

Fishing gears used and fishing seasons	**Yes**		**No**		**Not decided**		**Total No. of respondents**	**%**
	No. of respondents	**%**	**No. of respondents**	**%**	**No. of respondents**	**%**		
Application of mono filament gillnet to harvest small sized fishes.	63	61.76	29	28.43	10	9.8	102	100
Fish harvesting in the whole 12 months in a year	39	38.2	52	50.9	11	10.7	102	100

Table 10. Responses of fishers from cooperative on fishing gear used and time of fishing.

Fishing gears used and fishing seasons	Respond "Yes"		Respond "No"		Not decided		Total No. of respondents	%
	No. of respondents	%	No. of respondents	%	No. of respondents	%		
Application mono filament gillnet to harvest small sized fishes.	1	4	24	96	-	-	25	100
Fish harvesting in the whole 12 months in a year	-	-	25	100	-	-	25	100

According to the above findings and from researcher's own observation and key informant discussion, the mesh size of the majority of individual fishers, was less than 8 cm and there is continuous fishing activity throughout the year.

Different research findings indicated that deployment of gillnets less than 8 cm will harm the fish resources. In recent years, there has been a major concern that the gillnet mesh size reduction may have affected the reproduction stage of fishes, before they reach sexual maturity in most Ethiopian high land lakes (Hamley 1975 cited in EFASA, 2011; Von Brandt, 1975 cited in Elias Dadebo, 2012).

Another possible threat for the decline of fishes in Lake Hayq is continuous fishing for all the 12 months without gap even during reproductive seasons of fishes. Except few (3.92%) the majority (96.08%) of individual fishermen, had the information when actually the fishes reproduce (season of reproduction), But, individual fishers are continuously fishing in large numbers during reproductive seasons, because there is no

continuous follow up of the lake's resources and there is no continuous awareness creation within the fisher's community.

Individual fishermen were asked on why they are fishing using smaller mesh sizes and during the breeding times. Their response was that "this lake is our gift from GOD to sustain our life" and in order to sustain their life they must do fishing by all means and they had to use fishnets having mesh sizes less than 8 cm to target tilapia, which otherwise could have escaped as the tilapia are stunted. They were forced to fish during the breeding time as it is a question of survival, in which they have no other employment options during that time.

It is believed that the opinion and actions of the above fishermen was due to lack of awareness about the consequences of overexploitation on the sustainability of the lake's resources as well as absence of alternative livelihood sources.

Studies by FAO (2006 cited in Tarekegn Shado, 2006) indicated that limited alternative employment opportunities as constraint to the small-scale fisheries to contribute to food security and alleviate poverty. Similarly, a study conducted by DFID (2001 cited in Tarekegn Shado, 2006), in Ghana has shown that over reliance on one type of resource and lack of options are among the major constraints of livelihood of small-scale fishermen. This has been confirmed, too, that lack of alternative employment opportunities for the fishermen and the urban unemployed youth has caused overdependence on ever depleting fishery resource of Lake Hayq, which is currently an open access resource.

3.4.2. Other factors contributing to the declining fishery in Lake Hayq.

Survey result from all (100%) members of Logo Hayq–Ardibo fishermen association, as well as, 99.2% individual fishers has indicated that the current fish production has shown significant reduction since fishermen started fishing on Lake Hayq. The idea is supported by the discussion from local elders, key informant interview and own observation.

Factors that cause current fish decline in Lake Hayq from the perception of members of the association, individual fishers, field observation and discussion with key informants are presented as follows:

1. Increased number of individual fishers due to low employment diversification, insufficient farm land and insufficient yield from farming to support their household.
2. Application of inappropriate gillnet (<8cm mesh size).
3. Fishing during reproduction seasons.
4. Destruction of reproductive sites of fishes through destruction of shore line vegetation by grazers & expanding farm lands (Figure 11).

Figure 11. The current situation of Lake Hayq with water shore line destruction

The catchment and shore of the lake have been highly degraded (Seyoum Mengistou, 2006 cited in Tadesse Fetahi *et al*., 2013). The degradation of the lake shore and grazing of macrophytes by cattle destroys the availability of spawning habitats of *O*. *niloticus* and other fish species.

5. Lake water level reduction (Fig. 12) caused by drought and inflow water reduction of Ankerka River, expansion of farm lands and deforestation on the shore line, that cause soil erosion & flooding to the lake and as a result, the soil sedimentation aggravated the decline in water depth. All of the survey respondents and key informants agreed that they have observed significant decline of the water level of Lake Hayq.

Figure 12. The current situation of Lake Hayq with water level reduction.

The interview from two local elders indicated that the previous (40 years before) shore position of Lake Hayq on the west side of the lake, has about 200 m difference from the present shore location. They have associated the causes to the irrigation need of the growing population, the use of the lake's water and particularly the single inflow river (Ankerka) for cultivating crops, vegetables," Chat" etc. and the reduction of rainfall over time (Figure 13).

According to Dagnachew Melaku and Abate Shiferaw (2014), the width of the isthmus of Lake Hayq has increased from 33 meters, to 108 meters and 163 meters in the years 1972, 1986 and 2012, respectively, the lake's depth has decreased to 88.2 m to 81m in the year 1941 and 2007, respectively.

Figure 13. Lake water used for irrigation purpose

6. Environmental pollution from fertilizers, road construction camp oil discharges during 2008 and urbanization on the Lake Hayq surrounding.

According to Amare *et al.* (2014) is the prevalence of parasitic helminthes in fishes. Infected *O. niloticus* (Nile Tilapia), *C. gariepinus* (African Catfish) and *C. carpio* (Common Carp) in Lake Hayq indicated that the prevalence of internal parasitic infections was very high and the above study determined six parasitic species present in fish, which were not previously reported in the lake.

7. Some respondents even suggest that introduction of common carp may have reduced the tilapia in number and size, which may require further research
8. Lack of awareness about appropriate fishing or wise use of lake resource.

There is a gap between the fishing community and the responsible government authority in the application of the proclamations ratified by federal and regional governments, because 90.2% of fishermen were not informed about the proclamations. Majority of fishermen in both focus groups were not given any awareness or training about appropriate lake resource management system from responsible government sectors.

9. Inefficient Lake Management system, low attention from responsible stakeholders, fishery community and Lake Hayq surrounding communities.

Similar findings have been reported regarding management problems of lakes in Ethiopia. For example, Eshete Dejen (2011) has stated that Lake Tana's ecosystem and water resources as a whole are endangered due to deforestation, erosion, sedimentation, water level reduction, erratic rainfall, flooding of the wet lands, competing use of water resources, increased pollution and pressure of the growing population. There is also lack of official fisheries management with a free license (open access or an absolutely unregulated fishery), which results in the lack of transparency and effectiveness. This problem, which arises in both developed and developing countries leads to management authorities having poor accountability to the fisheries sector and the public (FAO, 1999 cited on Felegeselam Yohannes, 2003).

Based on the result from research participants in this study, this study identified that the **most leading factor** is uncontrolled overexploitation of fishes by illegal fishers using fishnets with mesh size of less than 8 cm. Moreover, other external factors that degrade ecological balance of the resource and inefficient management due to inappropriate policies and institution aggravated the situation.

3.5. Suggested lake management measures

To avoid fish destruction and to improve fish yield in Lake Hayq, both groups of fishermen, respondents from hotels and restaurants, and discussion with key informants suggested the following management tools:

1. Licensing and limiting the number of fishermen.
2. Controlling individual fishers from using gillnets with mesh size less than 8 cm. and protect the lake from fishing during fish reproductive seasons.
3. Creating awareness to fishing communities about sustainable lake resource usage and continuous professionals follow up and attention.
4. Effective lake management system to protect the lake resource from pollution, expansion of farm lands towards lake shore, shore line grazing etc.
5. Facilitate employment and job diversification to youths.
6. Organize individual fishers into fishermen association.
7. Facilitate inflow water channels during rainy seasons to improve water level of the lake with proper baseline land management system including reforestation, terracing etc.
8. Further investigation into the problems of stunting of the tilapia in the lake. According to the field observation, discussion with individual fishers, there is growth problem and the age at maturity in this species in recent years (Fig. 14)

Figure 14. Fisherman showing mature eggs from stunted tilapia

9. Community participation, as many natural resources have been degraded due to exclusion of the resource users in decision making and management systems

10. Temporary closure of areas where fishing is prohibited and prevent the lake from fishing for about 1-2 years to recover the fish resources.

The direct resource users even illegal fishers agree with most of the management solutions and they are motivated and show willingness to share management responsibility. From this study we have learned that if individual fishers are continuously given the chance to be aware about the appropriate fishing system with required support to this sector, the fishers of Lake Hayq can change their inappropriate fishing trends and as a result the fish resource will undoubtedly be recovered.

CHAPTER FOUR: CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The present findings can be summarized as follows:

- Lake Hayq's fish species diversity are consisting of only four species, namely tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), Carp (*Cyprinus carpio*) and Garra (*Garra dembecha*) , the last has no economic value in the locality.

- Tilapia is more abundant in the lake as a whole, and also in the lake shore. Catfish. is rare in the dry season (Begga), but more abundant in the rainy season (Kiremt). However, according to respondents, the relative abundance of fish species particularly tilapia and catfish showed considerable reduction in recent times, whereas, carps showed better adaptation and flavor quality since introduced into Lake Hayq.

- The fish resource obtained from Lake Hayq support more than 400 fishermen as a means of livelihood and used as a protein source for the surrounding communities. However, the current fish resource status of Lake Hayq is showing remarkable decline, mainly, as a result of high number of fishers and inappropriate fishing practices. The lake resource is expected to be completely depleted if appropriate measures are not immediately taken.

- There is no adequate support from the government for this sector.

- The fish resource is more threatened by human activities particularly overfishing of fishes by individual fishers who continuously fish throughout the year including fish reproduction seasons by applying non recommended gillnets that have mesh sizes less than 8 cm.

- The situation is aggravated by the increase in population, little employment opportunities for youth, and absence of effective lake management system.
- Other human trends that aggravate the situation include pollution from extensive agricultural practices.
- Destruction of shore line vegetation where fishes use to spawn, through grazers & expansion of farm lands as a result of rural population growth.
- Lake water level change as a result of soil sedimentation, irrigation, erratic rain fall and evapo-transpiration.
- Lack of awareness about proper fishing and lake management system.

4.2. Recommendations

The following recommendations are suggested regarding fishery resources and biodiversity loss in Lake Hayq:

- There is an urgent need for fisheries regulations which would restrict the number of fishers or fishing effort. The open access characteristics of the fishery resource increased the number of fishermen, which in turn leads to stock depletion and economical bankruptcy to the fishery industry. So exclusive fishing rights are considered as a solution to these problems.

- The threat on tilapia and African catfish needs immediate action. Proper investigation on the cause (s) of stunting of tilapia needs to be conducted and remedial measures need to be taken.

- There is a need to organize individual fishers into fishermen association to be governed by proper regulation.

- There is also a need to properly budget and financially support permanent fishery experts or professionals for consistent lake resource conservation.

- In order for the fish stock to replenish under the present condition, all the fishermen in Lake Hayq should stop fishing for a certain period of time (at least for about two years) to ensure sustainability of the fish resources to the next generation.

- The local government has to facilitate employment diversification (alternative livelihoods) to individual fishers, especially for those who are totally dependent on Lake Hayq fish resources.

- Effective land and lake management systems should be in place.

- Proper monitoring of the physico-chemical parameters of water is important to ensure successful fishery management plans.

- Commitment to involve community members and local institution in the management and conservation of natural resources. Community participation is very essential for resource management as many natural resources have been degraded due to exclusion of the resource users in decision making and management systems.

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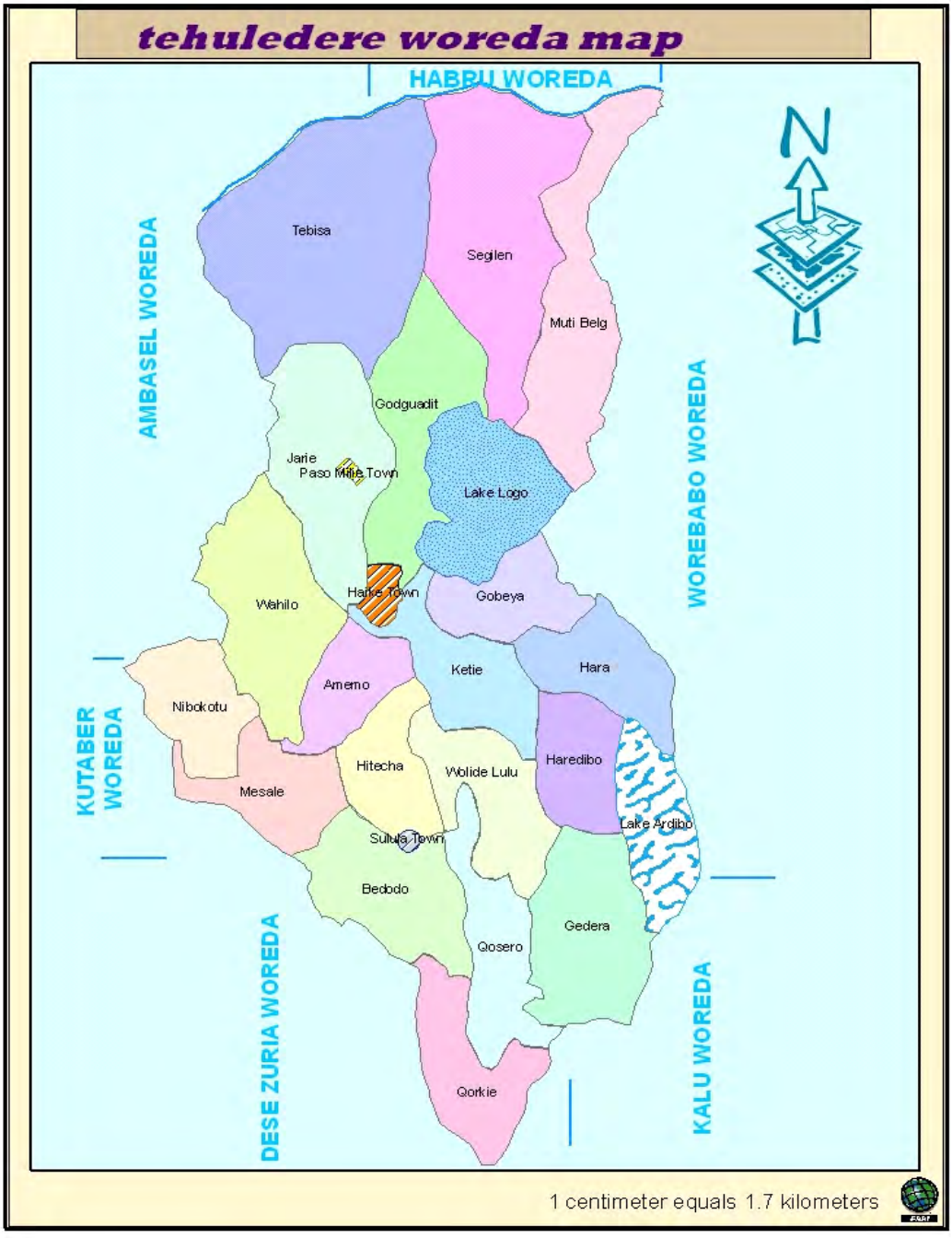
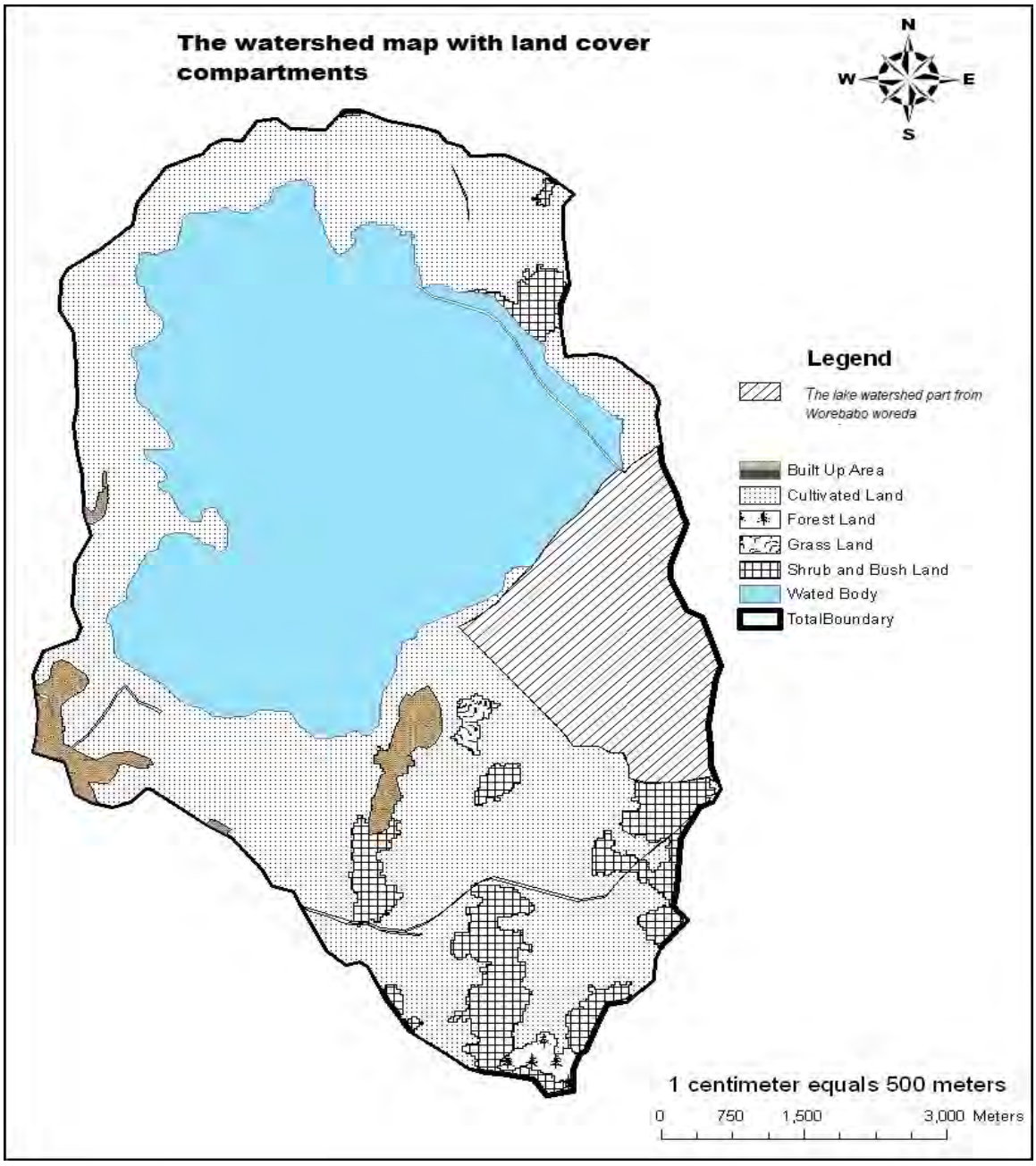
APPENDICES

Appendix 1. Maps of Tehuledere Woreda and Lake Hayq.(from Tehuldere Woreda Agriculture and Rural Development Office)



Tehuledere Woreda map.



Lake Hayq water shade map with land cover compartments

Appendix 2. Figures captured during field observation of present study.

Size difference between tilapia and Common carps

Size comparison of Common carps from African catfish in Lake Hayq.

Fishermen being interviewed at fish marketing site in Haik Town.


Fishing gears (fishnet and hook with corn).

Unsafe (poor sanitation) fish markate place in Haik Town.

During shoreline observation.

Destructed shoreline.

Catchment urbanization.

Discussion with local elders about past physical trends of Lake Hayq.

During discussion with former fishermen about past fishing trends.

Appendix 3. Questionnaire sample.

Addis Ababa University, Collage of Natural and Computational Sciences

Department of Zoological Sciences Summer MSC Program.

"Assessment of the fish diversity, Abundance, Socioeconomic Importance and Impacts of Overfishing in Lake Hayq South Wollo Ethiopia. "

These questionnaire have been developed to collect data about the diversity, abundance of fishes and socio economic importance of the fishery in Lake Hayq, and to suggest measures in order to conserve the Lake from over-exploitation and protecting the water resources against degradation from other competitive use. The researcher assures that the information gathered is intended for research purpose only.

Thank you for your time and valuable information

Part I: Questionnaire for non members of fisher's co-operatives

No need of writing your name

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

1. Sex: Male ☐ Female ☐

2. Age- (in year): 14-20 ☐ 21-30 ☐ 31-☐ 41-☐
50 ☐ ve 50

3. Education: a. No formal education ☐ b. Formal education 1-4 ☐ 5-8☐
9-10 ☐ 11-12☐ diplom☐ first degre☐

4. Marital status: single ☐ married ☐ Divorce☐ Widowe☐

5.Family members(size): ☐

6. Fishing experience(in years): 1-5 ☐ 6-10 ☐ 11- 1☐
16- 20☐ 21-30 ☐ above 30 ☐

7. What was your reason to start fishing? _____

_____

8. The house in which you are living is? - private ☐ - your family's ☐

-Rental ☐ - Relatives ☐

9. How far you travel to sell your fish? (in Km) _____

10. How many species of fishes did you get from Lake Hayq?

Their Names: _____,_____,_____,_____

About abundance of fishes

No.	Abundance & market value	Tilapia	African cat fish	Common Carp	Garra spp.
11	Which species of fish is more available in the Lake as a whole?				
12	Which species of fish is more available around the shore?				
13	Which species of fish is more available in summer?				
14	Which species of fish is more available in winter?				

Economical status of individual fisher men

15. Which species are more chosen by your customer?_____, _____

Its accessibility in the Lake: a. High ☐ b. Lo ☐ C. Very ☐

16. Average amount of fish you harvest (Kg/ day) _____

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

A. direct to consumer ☐

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

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

A. The whole fish ☐

B. Processed: Fillet ☐ Cocked ☐

19. Market price of fish (Birr/Kg) _____

20. Your income per month-about _____birr. 750-1000 ☐ 1100-150☐

1600-2000 ☐ Above 200 ☐

21. If you are not fulltime fishermen, what are your other means of income?

_____

Which one give you better income?_____

Economical status of fishermen, fish production status & awareness about their practices.

No.	Economical status and awareness	Yes	No	Not decided
22	The fish species more needed by consumers			
23	Do you have other income in addition to fish collection ?			
24	Do you get any support from professionals how to use the Lake resource ?			
25	In the last five years could you harvest sufficient amount of fish from this lake to support your family ?			
26	Is the quantity and quality of fish you obtained satisfying your customers?			
27	Do you use narrow filament (mesh size less than 8 cm.) to harvest even small sized fishes?			
28	Do You know the reproduction months of fishes?			
29	Do you harvest fishes from this lake all 12 months in a year?			
30	Are you volunteer to stop harvesting fish during breeding season of fishes?			
31	Have you ever been given awareness or training on wise use of fisheries resources?			

32. Why are you not a member of Logo Hayq- Ardibo fishers co-operatives?

_____

_____

_____

_____

33. How do you think fisheries production has changed since you have started fishing on the Lake? a. Increased ☐ b. Decreased ☐

c. Same amount ☐ d. No opinion ☐

34. What are the reasons you think for fish declining in the lake?

_____

_____

_____

_____

35. Do you know about the Ethiopia's fisheries development and utilization proclamation 315/ 2003 (1995 ☐ Yes ☐ No

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

Agree ☐ Disagree ☐ .

How? _____

_____.

37. Are you volunteer to use recommended fishnet (With 8-10 cm opening) to avoid collecting small young fishes _____

38. If your answer is **NO** for question 34, what are your reasons_____

_____

_____

_____

_____

39. Do you believe other factors also contributed in the declining of fishes in the lake?

_____

40. If your answer is **yes** for question 36, please list out the possible factors you think ;-

_____
_____
_____
_____
_____

Which of these are more significant_____
_____

41. What measures you suggest to avoid fish destruction and to improve fish yield in lake Hayq?(you can choose more than one)

a. licensing and limiting the number of fishermen ☐

b. Closed season when fishes are reproducing ☐

c. Temporary closure of areas where fishing is prohibited ☐

d. Others you think_____

_____
_____
_____

Addis Ababa University
Collage of Natural and Computational Sciences
Department of Zoological Sciences Summer MSC Program

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These questionnaire have been developed to collect data about the diversity, abundance of fishes and socio economic importance of the fishery in Lake Hayq, and to suggest measures in order to conserve the Lake from over-exploitation and protecting the water resources against degradation from other competitive use. The researcher assures that the information gathered is intended for research purpose only.

Thank you for your time and valuable information

Questionnaire/ Interview to Logo Hayq- Ardibo fishermen association office

1. When was this fishermen association established? _____years.

2. Number of fishermen in your association _____ Male ____ Female _____

- Urban _____
- Rural _____

3. From which Lake do you get better catch of fishes?_____

4. Amount of fishes captured by each members per day_____

5. Number of boats you used: Motorized ☐ Wooden ☐ Others ☐

6. Sizes of gear(fishnet filament size) you used in Cm _____

7. From where do you obtain the gear(fishnet) you used? _____

8. Method of preservation _____

- Number of refrigerators _____

9. Means of transportation _____, _____, _____

10. Market destination towns _____,_____, _____, _____

11. In which town are you selling more Fishes?_____ _____

12. Market price of fish (birr per Kg)? _____

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

A. Direct to consumer ☐ B. Traders ☐

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

14. Average amount of fish harvesting by each member in Kg/day? _____

15.Do you think you are satisfying your customers in terms of quality and quantity of fishes from Lake Hayq in these few years? a. Yes ☐ b. No ☐

16. If your answer is **NO**

why?_____

_____

17. Do you know about the Ethiopia's fisheries development and utilization 315/2003 (1995 EC)? a. Yes ☐ b. No ☐

15. Have you ever been given awareness or training on wise use of fisheries resource?

a. Yes ☐ b. No ☐

16. Are there any supports from government offices and professionals for your fishing activity?

☐ ☐

a. Yes b. No

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

_____,_____,

_____, _____

17.The reasons more you shifted from Lake Hayq to Lake Ardibo in the last few years?

_____,_____,

_____,_____

18. What factors are contributing for fish declining in Lake Hayq? (you can choose more than one)

a. overfishing by illegal fishermen ☐ b. Irrigations ☐

c. Decreasing Lake depth due to poor land management system ☐

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

_____

_____

_____

20. Do you believe Government bureau working effectively to alleviate the problem?

a. Agree ☐ b. Disagree ☐ c. No opinio ☐

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

22. If your answer is yes for question No 21, what are they? _____,

_____, _____

_____, _____, _____.

23. What are the important measures you suggest to avoid fish declining?

_____,_____

_____,_____

_____,_____.

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Thank you for your time and valuable information

PART III: Questionnaire to Logo Hayq-Ardibo fishermen Association members

No need of writing your name

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

1. Sex: Male ☐ Female ☐

2. Age- (in year): 14-20 ☐ 21-30 ☐ 31-☐ 41-☐
50 ☐ ve 50

3. Education: a. No formal education ☐ b. Formal education 1-4 ☐ 5-8 ☐
9-10 ☐ 11-12 ☐ diplom ☐ first degre ☐

4. Marital status: single ☐ married ☐ Divorce ☐ Widowe ☐

5.Family members(size): ☐

6. Total fishing experience(in years): _____

a. individually _____ b. In this cooperative _____

7. For about how many years working in this fishermen cooperative? _____

8. What was your reason to start fishing? _____

_____

9. The house in which you are living is? - private ☐ - your family's ☐
- Rental ☐ - Relatives ☐

10. How far you travel to sell your fish? (in Km) _____

11.How many species of fishes did you harvesting from Lake Hayq?

Their Names: _____,_____,_____,_____

About abundance of fishes

No.	Abundance & market value	Tilapia	African cat fish	Common Carp	Garra spp.
12	Which species of fish is more available in the Lake as a whole?				
13	Which species of fish is more available around the shore?				
14	Which species of fish is more available in summer?				
15	Which species of fish is more available in winter?				

Economical status of fisher men (members of logo Hayq-Ardibo Association)

16. Which species are more chosen by your customer?_____, _____

Its accessibility in the Lake: a. High ☐ b. Lo ☐ C. Very ☐

17. Average amount of fish you harvest (Kg/ day) _____

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

A. direct to consumer ☐

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

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

A. The whole fish ☐

B. Processed: Fillet ☐ Cocked ☐

20. Market price of fish (Birr/Kg) _____

21. Your income per month-about _____birr. 750-1000 ☐ 1100-1500 ☐

1600-2000 ☐ Above 200 ☐

22. If you are not fulltime fishermen, what are your other means of income?

_____

Which one give you better income?_____

No.	Economical status of fishers, fish production and awareness	Yes	No	Not decided
23	Which species of fish is more needed by consumers?			
24	Do you have other income in addition to fish collection ?			
25	Do you get any support from professionals how to use the Lake resource ?			
26	At the present condition do you harvest sufficient amount of fish from lake Hayq to support your family ?			
27	Is the size and quality of fish you obtained from lake Hayq are satisfying your customers?			
28	Do you use any sized gear(fishnet even with narrow opening) to harvest any size fishes?			
29	Do you harvest fishes from Lake Hayq all 12 months in a year?			
30	Do You know the reproduction months of fishes?			
31	Do you have rules & regulation that prevent you from harvesting fish during breeding season?			
32	Have you ever been given awareness or training on wise use of fisheries resource?			

33.What advantages have you ever get by being member to the fishermen association?

_____

_____

_____

34. How do you think fisheries production has changed since you have started fishing on the Lake? a. increased ☐ b. decreased ☐

c. same amount ☐ d. No opinion ☐

35. What are the reasons you think? _____

_____

_____

_____

36.The reasons more you shifted from Lake Hayq to Lake Ardibo in the last few years? _____,_____,

_____,_____

37. What factors are contributing for fish declining in Lake Hayq? (you can choose more than one)

a. overfishing by illegal fishermen ☐ b. Irrigations ☐

c. Decreasing Lake depth due to poor land management system ☐

If any others you believe other factors , please list out the possible factors you think ;-

_____

_____

_____

38. Do you believe Government bureau working effectively to alleviate the problem?

a. Agree ☐ b. Disagree ☐ c. No opinio ☐

39. What measures you suggest to avoid over fishing in order to improve fish yield in lake Hayq?(you can choose more than one)

a. licensing and limiting the number of fishermen ☐

b. closed season when fishes are reproducing ☐

c. temporary closure of areas where fishing is prohibited ☐

d. others you think_____

_____

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"Assessment of the fish diversity, Abundance, Socioeconomic Importance and Impacts of Overfishing in Lake Hayq South Wollo Ethiopia. "

These questionnaire have been developed to collect data about the diversity, abundance of fishes and socio economic importance of the fishery in Lake Hayq, and to suggest measures in order to conserve the Lake from over-exploitation and protecting the water resources against degradation from other competitive use. The researcher assures that the information gathered is intended for research purpose only.

Thank you for your time and valuable information

Questions developed to Hotels and Restaurants

1. Region _____ Zone _____Town _____

2. working experience in this field _____

3.From which Lake do you got fishes before five years? _____,_____

4.How many types of fishes you obtained? What are they?

_____,_____,_____

5.Which species are more chosen by your customer? (please order them 1-4)

a. Tilapia ☐ b. Cat fish ☐ c. Common carp ☐ d. Gara ☐ spp.

6. The accessibility, quality or size of fishes before five years you obtained are was better or not when you compare with current fish supply from Lake Hayq are:- a. poor ☐

b. good ☐ c. very good ☐

7. In these few years the demand of fish food by your customer is:- a. Increasing ☐ . b. decrea ☐ c. no diff ☐ e

8. Which kind of food you are preparing from fish for your customers? _____

_____,_____,_____,_____

9. Which one is more preferable by your customers? _____,_____

10. Which type of species of fish are required to prepare food that are preferred in question No. 10?_____ , _____

11.Did you get sufficient amount of fishes from Lake Hayq in the recent few years?

a. Yes ☐ b. N ☐

12.If your answer is **no** for question no.11 what are the factors you think?_____

_____

_____

_____

13. Where did you get more fish to satisfy your customers in these few years?

a. Lake Hayk ☐ b. Lake Ardibo ☐

c.Kombolcha fish distributers (from Tana, Zway) ☐

15. Which have better accessibility and supply of fish for your business?

a. Lake Hayq ☐ b. Lake Ardibo ☐ c. Other La ☐

16. How can you explain Hotel and Tourism value of Lake Hayq?

_____

_____

_____

_____

17. What are the factors you believe about fish declining in Lake hayq?

_____

_____

_____

_____

18.What measures you suggest to avoid fish destruction to improve fish yield in lake Hayq;-_____,

_____

_____

_____

_____

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Interview Guide for Experts and Respective Local Government Bodies in Woreda Agricultural and Rural Development Department

Qualification _____ Position _____ Experience _____
Sex : Female ☐ Male ☐

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

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

_____

_____

3. Does the regional government made plan in fisheries development and management?_____

4. Have the fishermen ever been given awareness or training on wise use of fisheries resources by a concerned Woreda or Zonal Bureau?_____ If yes, please give some details about the awareness creation/training.

_____
_____

5. Does your organization give technical back up to the fishermen? _____.

If there is, please list type of support you are giving:-

_____

_____

_____

6. Do your organizations give some sort of fishing license or permission? _____

7. Are there defined criteria? _____

_____

_____

_____

8. Are there any rules and regulation of fishery management on Lake Hayq? _____

9. How do you control and manage the fish resource exploitation in Lake Hayq?

What are your management tools?

_____

_____

_____

10. If not what are the major reasons? _____

_____

_____

_____

11. Do you think that the resource management is effective and efficient? _____

12. If not, What do you suggest to alleviate the problem?

_____

_____

_____

13. What regulatory framework (rule or direction) is available? How does the availability or unavailability of regulatory framework affect management of fishery in the area?

_____
_____
_____
_____
_____
_____

14 Are there any external factors that are out of the Wereda's agriculture office mandate/authority that affect the regulation of Lake Hayq's fisheries production? If yes, what are these factors ?

Natural factors ☐ Institutional factors, policies, laws ☐
Political factors ☐
Others (specify) _____
_____

15. Who do you think should be involved in the proper and effective management of the fishes and fisheries to ensure sustainability (e.g. local government, agriculture bureaus, fishermen [both individual and cooperatives], entire local people, etc)?

_____
_____
_____

_____