ASSESSMENT OF FISH DIVERSITY AND COMPOSITION IN ALWERO RESERVOIR, BARO AKOBO BASIN, SOUTHWEST ETHIOPIA

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On

Fish diversity and composition in Alwero reservoir, Baro Akobo Basin, Gambella region, southwest part of Ethiopia, 2019

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DECLARATION

I, the undersigned, declare that the study entitled “Assessment of fish diversity and compositionin Alwero reservoir, Baro-Akobo basin, Southwest Ethiopia,’’is my original work and has not been presented for a degree in any other university, and that all sources of material used for the study were correctly acknowledged.

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ABSTRACT

This study was conducted to assess diversity and composition of fishes, identify relative abundance, and determined the length weight relationship and condition factor for the most abundant fish species in Alwero Reservoir located in Baro-Akobo Basin, Gambella Region, Southwest Ethiopia. Additionally, some environmental factors related to fish abundance were also studied. Fish specimens were collected from selected sites using gill nets of various mesh sizes (6cm, 8cm 10cm, 12cm, 14cm, 16cm). Fish sampling was done in two months, one for dry season (May, 2018) and one for wet season (October, 2018). A total of 427 specimens were caught from the reservoir. These were identified into 17 species, 16 genera, 13 families and 6 orders. Shannon diversity index for the reservoir is 1.6. Family Mormyridae was the most diverse consisting three species. Cilchlidae, Citharinidae, Alestiidae and Auchenoglanidae were the best represented families with respect to abundance constituting 223(52.2 %), 84 (9.67%), 36 (8.43%) and 26 (6.09%) of the total catches respectively. Oreochromis niloticus (63.78% Index of Relative Important), was the most represented fish species in terms of number, weight, frequency of occurrence and Index of Relative Important in Alwero reservoir. Analysis of the Length-weight relationship for the most abundant species showed that the relationship was strong by reffering b-value for Oreochromis niloticus (b-3.027) attains isometric growth, positive allowmetric growth for both Brycinus macrolepidontis (b-3.228) and Auchenoglanis occidentalis (b-3.195) and negative allowmetric growth for Citharinus citharus (b-2.85). Seasonal variations in the mean Fulton Condition Factors of the most dominant species were statistically significant ($P<0.05$). In the present observation, most of the physicochemical parameters of reservoir were conducive for growth of fish fauna. Chlorophyll a, pH and temperature appeared to be the most important in the structure abundance of fish species among measured environmental factors in CCA analysis. Since some variables are negetively correlated, extra analyses on environmental factors are neccessary to give inclusive results on which parameters are the most important.

KEY WORDS: *Reservoir, Fish diversity, Length-weight relationships, Condition factors, water quality.*

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ABBREVATION AND ACRONYMS

Chllo a: Chlorophyll a

DO: Dissolved Oxygen

EC: Electric Conductivity

FCF: Fulton's Condition Factors

ICOLD: International Commission on Large Dams

IRI: Index of Relative Importance

JERBE: Joint Ethio-Russian Biological Expeditions

LWRs: Length-Weight Relationships of fish

PAST: Paleotological Statistics Software

pH: Potential Hydrogen on acidity level

Spp.: Species

WT: Water Temperature

USEPA: United State Environmental protection Association

1. INTRODUCTION

1.1.BACKGROUND

The construction of artificial reservoirs has been one of the most important modifications of natural river environments (Hladík *et al*., 2008). According to Tessier *et al*., (2016), Reservoir is the only semi-natural ecosystems, usually being the result of humans having transformed a river into a lake, with a sometimes poorly adapted and consequently highly dynamic aquatic fauna. Reservoirs are created usually for a particular purpose either to generate electricity, irrigation or domestic usage worldwide. In addition to their role in providing water for these purposes, most reservoirs also play an important role in fish production and contribute significantly to the livelihoods of communities along their shores (Icold, 2013). Irrespective of the main objective, the Fish yield from such Reservoirs may constitute a substantial contribution to a country's total domestic Fish production (Assefa, 2014). However, the effectiveness of their contributions depends largely on adequate fish assemblages and proper management of the Reservoir fisheries (Mustapha, 2008).

Fishes are of immense value to humans like many other form of life since they have long been a staple item in the diet of many peoples in world. Today fishes form an important element in the economy of many nations while giving incalculable recreational and psychological value to the naturalist, sports enthusiast and home aquarist (Nelson, 2016). Fishes in rivers are generally well adapted to flowing water. The transformation of a river to a reservoir, therefore, poses a problem for the resident; mainly riverine species that are not adapted to the new conditions (Getahun, 2008). As consequences, local fish assemblages can be organised across space, since each species has different tolerance limits that vary across environmental gradients (Terra, 2010). According to Thomas *et al*., (2007), organisms that occur in a particular place may be classified as a community or an assemblage or composition, the meaning of terms varies among ecologists. The term community implies substantial and predictable interaction and multiple taxonomic groups, where as an assemblage is simply the group of species found together in a particular area. Ichthyofaunal composition is the total number of individual fish species that can be collected at a particular sampling location using single or combination of techniques (Yerima *et al*., 2017). Diversity indices combine the information on the number of species in an assemblage (richness) and their relative abundance (evenness). Fish community structure can provide potentially powerful tools for assessing aquatic environmental health (USEPA, 2016). Freshwater ecosystem with its resources is indispensable part of human life and therefore, sustains all terrestrial and aquatic ecosystems. The health of those freshwater ecosystems is visible in the wellbeing of the fish assemblage they support (Gebrekiros, 2016).

Freshwater ecosystems support large numbers of species of plants and animals. One important descriptor of a community is the number of species present and their relative abundances species including richness and diversity (Yerima *et al*., 2017). For the diversity of fishes, numerically, valid scientific descriptions exist for approximately 27,977 living species of fishes in 515 families and 62 orders worldwide (Nelson, 2006), however, many others remain to be formally described (Lévêque *et al*., 2008). When broken down by major habitats, 41% (covering < 1 % of Earth's surface) of species live in fresh water, 58% (covering 70 % of Earth's surface) in marine water, and 1% move between fresh water and the marine during their life cycles (Nelson, 2016). Geographically, the highest diversities are found in the tropics. The Indo-West Pacific area that includes the western Pacific and Indian oceans and the Red Sea has the highest diversity for a marine area, whereas South America, Africa, and Southeast Asia, in that order, contain the most freshwater fishes (Berra 2001; Lévêque *et al*., 2008). A better understanding of the role of fish diversity in the functioning of ecosystems should be a precondition before manipulation of African inland waters is undertaken (Vijverberg *et al*., 2012).

Ethiopia, with its different geological formations and climatic conditions, is blessed with considerable water resources and wetland ecosystems, including river basins, major lakes, many swamps, floodplains and man-made reservoirs freshwater systems that confinements suitable for the growth of fish (Awoke, 2015). The total area of the lakes and reservoirs stands at about 7000 to 8000 km^2 and the important rivers stretch over 7000 km in the country (Janko, 2014), with more than 184 species of fish resources, 70 genera and 26 families (Golubtsov, 2008; Tewabe, 20120). Freshwater ecosystem with its resources is indispensable part of human life and therefore, sustains all terrestrial and aquatic life. The health of those freshwater ecosystems is visible in the wellbeing of the fish assemblage they support (Gebrekiros, 2016). Evaluating fish assemblage has been integral to water monitoring and water quality management programs for many years (US EPA, 2016).

Though Ethiopia is blessed with water bodies that contain a high diversity of aquatic fauna, the study of the freshwater fish fauna diversity is far from complete (Getahun, 2005). Since most of the studies conducted on the Ethiopian water bodies were concentrated on large lakes and rivers, the medium to small sized water bodies of the country remain less explored and several of them are not familiar to scientists (Tesfaye and Wolff, 2014). The freshwaters of the East African nation of Ethiopia are sub-divided into nine main drainage basins. One of these, the Baro-Akobo basin, is drained by the White Nile whose main tributaries are Baro (Openo), Gilo and Alwero, Akobo and Pibor with high fish diversity within country (Golubtsov, 2008). Alwero reservoir is the only dam in the Baro-Akobo basin built on the Alwero River. Some development activities also occur in the basin, so these could bear potential impact on the diversity and ecology of the basin's fish fauna (Molnar, 2014).

1.2 STATEMENT OF THE PROBLEM

The decline in abundance of freshwater fish in the world has been of concern for over one hundred years. Diversity of fish is lower in temperate regions and higher in tropical areas. For freshwater fish, the tropical zones of South America, Africa and Asia are the most diverse regions on Earth (Berra, 2001). Though Africa has a rich diversity of freshwater and marine fishes there is a little taxonomic expertise or funding to describe it (Ernst *et al*., 2008). The territory of Ethiopia encompasses parts of the catchment areas of two oceans, separated by the northern portion of the Great African Rift and two major biogeographic units, the Nilo-Sudan and East Coast Ichthyofaunal Provinces (Golubtsov *et al*., 2002), but its seems to be the least explored for their ichthyofauna among all the regions of African continent (Getahun, 2005). Most of the water bodies including the medium and small sized water bodies of the country are still not exhaustively studied (Tesfaye and Wolff, 2014). These small to medium water bodies of the country may surprisingly harbor high species diversity including Alwero reservoir, Baro-Akobo basin.

Ichthyofaunal explorations of Alwero River are undertaken as part of a JERBE work (Golubtsov and Berendzen, 1999; Golubtsov and Dzerzhinskii, 2003). Nonetheless, the Alwero (Alworo) river fish fauna is mostly known from field collections in lake at lower segments of its basin below the dam (Melake, 2012). This contrasts with the very few Ichthyological investigations that have been conducted at its upper reaches (Golubtsov and Dzerjinskii, 2003 Cited in Golubtsov, 2008). As consequence, little is known about the occurrences of the fish fauna in the upper reaches of this river, where major lakes remain largely sub-explored. This lake had been largely modified by man and his use of land and water (Deneke, 2013 and Molnar, 2014).

Species diversity and abundance reflect the quantity and quality of the available aquatic life. Studies pertaining to important ecological parameters like fish community structure, length weight relationship and condition factor and related physicochemical parameters do not exist for the basin except for the scattered reports on the morphological evidence for the occurrence of two electric catfish species *Malapterurus electricus* and *Malapterurus minijiriya* in Alwero river (Golubtsov and Berendzen, 1999); the species occurrence of the genus Phractura African Hillstream catfishes of the family Amphiliidae in upper part of the Alwero river (Golubtsov and Dzerzhinskii, 2003, cited in Golubtsov, 2008). Most of the previous explorations on the ichthyofaunal diversity of the basin (including, Getahun and Stiassny, 1998; Golubtsov and Berendzen, 1999; Golubtsov and Dzerzhinskii, 2003; Golubtsov and Mina, 2003), dealt with the main water bodies in Baro Akobo basins, White Nile system, they did not sample fish in the entire part of Alwero reservoir except for commercially important fish species in which about seven species were recorded from Alwero reservoir at Kano landing site (Abegaze *et al*., 2010). About 51 species belonging to 38 genera, 20 families and 11 orders were identified in some temporary and perennial water bodies of the Baro basin. Of these 51 fish species, a total of 30 species were recorded from Alwero River below the dam (Melak, 2012), with some taxonomic about to happen and unidentified few species in the basin. However, the data collection of these sampling methods often lacks consistency and uniformity at all landing sites across the reservoir. Hence, updated reliable information about patterns in the composition and structure of fish assemblages in this reservoir is particularly important. Despite the occurrence of some development activities, including proposed dam construction with potential impacts on ichthyofaunal diversity in Ethiopia, the Alwero reservoir generally lacks comprehensive data on species assemblage composition and diversity of fish with biological characteristics of fish's species and related environmental variables across the entire reservoir. Since, the change from a riverine in to a new limnic environment might affect its fish species composition, abundance and other dynamics in reservoirs. Therefore, this study is aimed to assess fish diversity, relative abundance of fishes, length weight relationships and condition factors of the dominant fishesas well as relationship between fish abundance and same related environmental factors of Alwero reservoir.

Research Questions

This study was provided answers to the following leading research questions:

What are the species composition and diversity of fishes in Alwero reservoir?

What does the biology (Length-weight relationship and Condition Factor) look like in the dominant fish species of this reservoir?

What is the relationship of fish species composition with environmental factors such as dissolved oxygen concentration, water temperature, pH, conductivity and Chlorophyll a in the Reservoir?

1.3 SIGNIFICANCE OF THE STUDY

The studies on species composition, some biological characteristics and information on environmental characteristics of Alwero River reservoir are virtually non-existent. Therefore, this study is aimed at assessing diversity, Length-weight relationship and condition factors of fishes of Alwero river reservoir as well as some related environmental characteristics that would help in the proper and sustainable exploitation of the fish fauna. The information provided by the study arises largely from the need to give recent data regarding fish diversity and composition. This can be useful in the proper and sustainable exploitation of the fish resources of Alwero Reservoir in Baro Akobo Basin and this may give an insight for future large scale research. The results of this study helpthe environmentalist, conservations and ecologist to develop species and habitat restoration in the future.

2. LITERATURE REVIEW

2.1. **Composition of Ethiopian Freshwater ichthyofauna**

From a biogeographical point of view, the vast majority of Ethiopian fishes belong to the obligatory freshwater groups representing the Primary Division of freshwater fishes in terms of Roberts, (1975). Two major biogeography units, the Nilo-Sudan and the East coast ichthyofaunal provinces are in contact to Atlantic and Indian oceans catchment, separated by the northern portion of the Great African Rift within the territory of Ethiopia (Golubtsov *et al*., 2002). That is why the country has Nilo-Sudanese and East African forms in addition to the endemic forms. However, recent analysis by Paugy, (2010) has modified the boundaries and numbers of ichthyofaunal provinces occurring within the Ethiopian territory as Nilo-Sudanic, East Coast, Ethiopian Rift Valley, Coastal Red Sea (CRS) and Lake Tana hotspot provinces. According to this new modification, the Nile sub-basins within Ethiopia and the Ethiopian southernmost Rift Valley lakes (Abaya, Chamo, Chew Bahr and Turkana) belong to Nilo-Sudanic province, and Lake Tana in the western highland stands on its own as Lake Tana Hotspot province. Lakes Hawassa, Langano, Abijata, Zeway and Awash River basin fall in a new province namely Ethiopian Rift Valley or Oromo province; lakes in the Danakil depression (Afdera, Assal) belong to the Red Sea Coastal sub-province, and the southeastern basins (Wabishebelle-Genale basins) become part of the Eastern province.These recent biogeographic analyses are very important when discussing the distribution of the fishes within Ethiopian freshwater (Wakjira, 2016).

According to Getahun, (2007), the Nilo-Sudanic forms are represented by a high number of species found in the Baro-Akobo, Omo-Gibe, and Abay drainage basins (e.g. members of the genera *Alestes, Bagrus, Citharinus, Hydrocynus, Hyperopisus, Labeo, Mormyrus, and Polypterus and Protopterus* etc.). According to Getahun and Stiassny, (1998), these Nilo-Sudanic forms are related to West African fishes and this is because of past connections of the Nile to Central and West African river systems.

Golubtsov *et al*., (2003), distinguished fishes endemic only to the Nile system and those endemic to the western portion of the Nilo-Sudan Ichthyofaunal Province, which includes the Nile basins, Omo-Turkana systems and Ethiopian Rift Valley. The Nilotic endemics with wider ranges of distribution (i.e. occurring in two or three elements of the western portion of the Nilo-Sudan

Ichthyofaunal Province, namely the Nile and Omo-Turkana systems and Ethiopian Rift Valley) are the mormyrids *Hippopotamyrus harringtoni, Mormyrus niloticus,* and *Petrocephalus keatingii;* cyprinid *Barbus yeiensis* and mochokids catfish *Synodontis caudovittatus;* mormyrids *Mormyrus caschive, M. kannume,* and *Pollimyrus petherici;* cyprinids *Garra* cf. *quadrimaculata, Labeo forskalii, L. horie, L. niloticus* and *Varicorhinus beso;* mochokid catfishes *Chiloglanis niloticus* and *Synodontis serratus* (Golubtsov *et al*., 2002).
The highland lakes (e.g. Tana and Haiq) and associated river systems, northern Rift Valley lakes (e.g. Lake Hawassa, Ziway, Langano) and the Awash drainage basin harbor the highland east African forms. These forms include the genera *Barbus, Labeobarbus, Clarias, Garra, Oreochromis,* and *Varicorhinus.* These forms are also related to fishes of eastern, northern, and southern Africa and some elements are shared with waters of western Africa. Awash and northern Rift Valley lakes almost lack the Nilo-sudanic forms. *Danakilia franchettii, Nemacheilus abyssinicus, Garra makiensis, Garrai gnesti*, and *Barbus* are the few species that represent the Ethiopian endemic forms (Getahun and Stiassny, 1998).

In considering these diversity and endemicity of fish fauna in the six main drainage systems of Ethiopia, there are no lacustrine endemics in the Wabi Shebele and Juba system, as well as in the White Nile system, while more than a half of endemics in the Blue Nile and Omo-Turkana systems, as well as in the Ethiopian Rift Valley, are lacustrine. Within the limits of Ethiopia, the White Nile, Omo-Turkana and Blue Nile systems accommodate the most diverse fish fauna composed mostly by the species widely distributed in the Nilo-Sudan Ichthyofaunal Province where as Wabi Shebelle, Juba and the Atbara-Tekeze drainage systems are the least fish fauna diversity (Golubtsov and Mina, 2003). According to Golubtsov and Darkov, (2008), though not supplemented with the actual list, the ichthyofaunal diversity of the nation has increased from 93 species (Tedla, 1973) to 184 (native) in 70 genera and 29 families, with 4-5 exotic species.At present, there appears to be no major active projects addressing ichthyofaunal assessments except for the pieces of MSc. /PhD theses often conducted under limited funding.

2.2. Fish diversity within drainage basins of Ethiopia

Ethiopian topography is characterized by elevated plateaus from which rise various tablelands and mountains. The walls of the highlands rise abruptly from the outer plains of lowlands on nearly every side and thus form a clearly marked geographic division. There are 9–12 drainage basins of freshwater system situated within these major physiographic units. The major basins are nine and these include Tekeze-Atbara, Abay (Blue Nile within the limit of Ethiopia), Baro-Akobo (White Nile Basin within the limit of Ethiopia) and Omo-Gibe (Omo-Turkana Basin within the limit of Ethiopia) basins in the western Highlands; Rift lakes, Awash River and Danakil Depression basins in the Rift Valley; Wabishebelle and Genale-Dawa basins in the south eastern highlands. Following the model of freshwater ecoregions of Africa, the freshwater systems of Ethiopia can be conveniently placed under five freshwater ecoregions. These are the Ethiopian Highlands (includes streams, rivers and lakes in the highlands of Ethiopia, but excluding Lake Tana, because of its unique fish fauna). The Northern Rift (rift valley lakes excluding, Lakes Abaya and Chamo because of the Nilo-Sudanic affinities of their fish fauna) the Lake Turkana (includes the Omo River and its tributaries as well as Lakes Abaya and Chamo). The Shebele Juba catchments (includes tributaries of Wabi-Shebele, Genale, Dawa and Fafan) and the Red Sea coastal (the Awash system and the saline lakes of northern Ethiopia that includes Lakes Abbe, Afambo, Afdera and Asale) drainage basins (JERBE, 2007).

These freshwater ecoregions can further be divided into six major drainage basins. These are: Tekeze Atbara, Blue Nile (Abay, Lake Tana, and Lake Hayq), White Nile (Baro-Akobo), Omo-Gibe-Turkana (Gojeb), Shebele-Juba (Ghenale) and Rift valley (Awash, Bishoftu crater lakes, Zeway, Langano, Abijata, Hawassa, Abaya, Chamo, Chew Bahir or Stephanie). Unevenness of the species within these main drainage basins could be due to highly diverse and rich habitat variation among the drainage basins, high exploration chance due to the relative accessibility of the lakes and rivers. The highest species diversity was recorded from Baro Basin, followed by Abay, Omo-Gibe, Tekeze, Wabi -Shebele Basins, Rift Lakes (Golubstov and Darkov, 2008).

2.2.1. Baro Akobo Basins (White Nile Basin)

The southwestern highlands of Ethiopia, South of the Abay trough, are relatively small mountain remnants rounded in form. Many of the tributaries of Baro-Akobo Basin arise from these mountains and hills. Baro-Akobo forms a White Nile Basin in Ethiopia in which Alwero, Gilo, Baro (Openo), Akobo, Baro Kela, Sore, Gabba, Birbir, Bonga and Jejebe Rivers are the major river systems. The two upper tributaries that coalesce to form Baro River, Birbir and Gabba, have their headwaters in the southwestern Ethiopian Highlands. Baro River flows west through the Gambella Region of Ethiopia to join with Pibor River to form Sobat River in South Sudan. The Sobat, as the Baro-Akobo is named outside of Ethiopia, derives its water supply mainly from the southern Ethiopian plateau (Getahun, 2003; Wakjira, 2016). Baro Akobo Basins has abundant fish resource from these various rivers and tributaries in which much of their production potential is expected to come from the floodplain areas including Lake Tatta, Alwero reservoirs & ponds found to be in the range of 15,417 and 17,308 tons per year (Abegaze *et al*., 2010).

JERBE expedition should be credited for its great role towards advancing the present day knowledge on the ichthyofaunal diversity of the country. Prior to the beginning of JERBE studies in this basin, only eight species were reported from White Nile drainage system within the limits of Ethiopia (Tedla, 1973) and is home to 91 species of fishes (Golubtsov *et al*., 1995). Golubtsov and Mina, (2003) indicates about 107 fish species belong to 54 genera and 23 families in the White Nile system within the territory of Ethiopia using original data on fish species composition. Getahun, (2007) reported that there were 87 fish species of which only one (*Afronemacheilus abyssinicus*) was endemic to this basin. About 113 fish species included in 60 genera and 26 families were recorded from the same basin during the past two decades (Golubtsov and Darkov, 2008). According to this work, only up to six families in Baro-Akobo river basin like Anabantidae, Channidae, Cromeriidae, Nothobranchiidae, Notopteridae and Protopteridae are not found in other Ethiopian basins. However, there is no data on exotic fish species in this drainage basin.

The diversity of fish fauna of Baro drainage basins contains a mixture of Nilo-sudanic (*Bagrus, Citharinus, Hydrocynus, Micralestus, Labeo, Mormyrus Pollymirus* and *Polypterus*), East African (*Barbus*, *Clarias*, *Oreochromis* and *Sarotherodon*) and endemic (*Garra*) forms (Getahun and Stiassny, 1998) but low level of endemism and this is probably because of the Baro Basin having connections (past and present) with the Nile and west and central African river systems and as a result, all the fish fauna represent widespread Nilo-Sudanic forms (Getahun, 2007). The most commercially important fish species are *Oreochromis niloticus*, *Clarias* species and *Polypterus bichir, Heterotis niloticus, Gymanrchus niloticus, Malapterurus* species*Lates niloticus*, *Alestes* sp. *Hydrocynus* species; *Mormyrops* sp. *Bagrus* sp., *Barbus* sp. and *Labeo horei* (Golubstov and Darkov, 2008). According to Abegaze *et al*., (2010), the region has a huge diversity of fish species though the bulk of the catch and the fish market are dominated by 19 genera and with more than 20 fish species. Of these 20 fish species, only seven species are identified from Alwero reservoir at Kano landing site.

Melak, (2010) record 51 fish species from Baro River and 10 species from Tekeze Basin of which three are endemic (*Garra duobarbis, Garra geba* and *Garra ignestii*). According to Melak and Getahun, (2012), a total of 51 species within 38 genera and 20 families were recorded in the Baro Akobo river basins. Of these 51 fishes species, a higher number of species were recorded from downstream of Alwero river dam 30 species, belonging to 8 genera, 14 families with some taxonomic pending and unidentified few species at all landing sites across the reservoir.

2.2.2. Abay (The Blue Nile) Basin

Blue Nile River originates in Lake Tana in the western Ethiopian Highlands. The present ichthyofaunal biogeographical analysis of Lake Tana and Blue Nile River seem to be demonstrated the isolating role of the Fall between the upstream and downstream fauna, since at 30 km downstream Lake Tana the Blue Nile River is interrupted by a 40 m high and 400 m wide Tissisat Fall which is the second largest in Africa (Vijverberg *et al*., 2009, cited in Wakjira, 2016). It is the major river of Ethiopia with a length of 1000 km between Lake Tana and the Sudan border and its annual discharge was around 50 billion cubic meters (Getahun, 2003), in which its systems are the Dinder River, which joins the Blue Nile far below the reservoir in the Sudan and a number of basins that include Jemma, Dabus, Beles and Didessa Rivers as well as Fincha and Koga basins and the, Lake Tana (largest lake in Ethiopia) and its tributaries (Beshilo, Walaqa, Jamma, Muger, Guder, Didessa and Dabus on the left bank and Gulla and Beles on the right bank in the downstream order are other major tributaries of Blue Nile Basin) (Habteselassie, 2012).

The Abay Basin is one of the tributaries of White Nile and consists of 36 species of fish which 23 are endemic (Getahun, 2007). Tedla, (1973), has reported 30 fish species from the Blue Nile drainage within the limits of Ethiopia. According to Golubtsov and Mina (2003) the number of indigenous species and endemics (in percentage) are 64 (36 %) in the Blue-Nile system (including the Lake Tana basin) while a review works done by JERBE, (2007), recorded 77 fish species belonging to 16 families and 37 genera. A quarter (19 species) of the total number of species recorded consisted of the cyprinids endemic to Lake Tana sub-Basin. The fish fauna of the Blue Nile system are less diverse than that of the White Nile system but the endemicity appears to be highest in Abay (Blue Nile) basin (Golubtsov and Darkov, 2008; Getahun, 2005). This is attributed, in the former case, to the endemic species flock of *Labeo barbus* and the presence of some endemic fishes adapted to localized habitats in small streams in the highlands of north and central Ethiopia (Getahun *et al*., 2008). It's believed that the lack of floodplains in the Blue Nile system, contributes to the lower fish diversity of this system. Also, the negative correlation of species diversity with altitude is quite pronounced in the Blue Nile system excluding Lake Tana (Golubtsov and Mina, 2003).

Lake Tana is the source of the Blue Nile in the northern highlands of Ethiopia. The Blue Nile drainage basin is well known of high percentage of endemic species (with at least 24 endemic species (Getahun, 2005). According to Beletew, (2007); Mohammed, (2010) a total of 17 fish species in upper head of Blue Nile River, belonging to five families (Cyprinidae, Clariidae, Bagridae, Mockokidae and Cichlidae); three orders (Cypriniformes, Perciformes, and Siluriformes) were recorded in Beshilo, Ardi and Dura Rivers of Blue Nile basin and among these, family Cyprinidae was the most dominant with eleven species that comprises (62.5%) the total number of species. Among these 17 fish species, 13 species are endemic to Lake Tana. A total of 23 fishes species belonging to 5 orders, 7 families and 13 genera respectively were recorded in Beles and Gilgel Beles Rivers of the Blue Nile Basin (Berie, 2007). Awoke *et al*., (2015) listed eight fish species composition for the Blue Nile River after the Tiss Issat fall. The fresh water fish's fauna of this basin contains a mixture of Nilo-sudanic form (included *B. docmak, B. bajad, H. forskhalii, L. forskalii, M. kannume, S. serratus* and *S. schall*), highland East Africa (e.g. *L. intermedius*, *L. nedgia*, *C. gariepinus*, *O. niloticus*) and endemic forms.

2.2.3. Tekeze- Atbara Basin

The drainage system includes tributaries of the Guang River (the Atbara River in Sudan) and tributaries of the Tekeze River, flows into the Nile after confluence of the Whit Nile and Blue Nile rivers in Sudan (Habteselassie, 2012). The area of this basin is about 84, 000 km^2. The elevation ranges from 537 to 4,517 meters above sea level. The Tekeze River basin is located in the northwest of Ethiopia, between 11°40' and 15°12' north and longitude of 36°30' and 39°50' east. The upper part of the basin is dominated by rugged mountains while the western part of the basin is almost flat or slightly undulating (Giday, 2002; Atismachew *et al*., 2006).

Until recently, there were less data on fishes of the Atbara-Tekeze system than on those of other Ethiopian drainage systems. The knowledge of the fish fauna of Tekeze-Atbara drainage system is unknown before the JERBE surveys of the region (i.e. there is no specified data for the number of fish species and endemism of this basin). Thus, the most data presented are from the surveys conducted in 1996, 1999 and 2003 by JERBE. Golubtsov and Mina, (2003), mentioned that Tekeze Basin is the least diverse in fish species compared to the White and Blue Nile basin within the limits of Ethiopia. This could be because of the tremendous seasonal variation of water discharge in the system. Golubtsov and Darkov, (2008), indicated that 34 fish species within 22 genera and 10 families were present in the river basin. This review work reported that the construction of dam on the Tekeze River should substantially change the river ecology and its effect on the local fish stocks has to be mentioned. Fish diversity has been assessed in Tekeze river basin and 10 species belong to four orders (Cypriniformes, Siluriformes, Perciformes, and Tetraodontiformes) and four families (Cyprinidae, Bagridae, Cichlidae, and Mormyridae) were recorded from this basin of which three are endemic (*Garra duobarbis, Garra geba* and *Garra ignestii)* (Melak, 2010).

2.2.4. Omo-Gibe (Omo-Turkana) Basin

Omo-Gibe River has its origin in the southwestern Ethiopian highlands at an elevation of 2, 200 ma.s.l. The major tributaries, in the upstream to downstream order, include Gojeb (the major one), Gilgel-Gibe, Amara, Alanga, Denchiya, Mui, Zigina-Shoshuma, Mantsa, and Usno (with sub-tributaries Mago and Neri).In Ethiopia, it largely lies in the southwestern highlands while its lower portion is also located in the eastern arm of the East African Great Rift Valley. The modern Lake Turkana is in a closed basin with no known surface outlet and characterized by moderate salinity of 2.89 g L-1 (Golubtsov and Darkov, 2008; Paugy, 2010). Evidences, however, rather suggest its historical connection to White Nile apparently via Lotigipi Swamps and Pibor River in northern Kenya and southern South Sudan.

The first organized expedition to the Omo-Turkana basin was undertaken as part of its East African Great Lakes expedition (Worthington 1931, 1932; Worthington & Richardo 1936). This has been followed by a French multidisciplinary scientific expedition to the lower Omo River valley (La mission scientifique de l’Omo, 1932–1933). A review by Tedla (1973) listed 23 species for the Omo-Turkana system, the majority of which being from Omo River system. The ichthyofaunal exploration by the Joint Ethio-Russian Biological Expedition (JERBE) listed 53 fish species occurring in the Omo River basin and 72 species in the entire Omo-Turkana system. A combination of these preceding studies and other reviews of early works results in 74 valid species for the entire Omo-Turkana system. However, Golubtsov and Darkov, (2008) later on increased the number of fish species lists to 76-79 valid native fish species belonging to 44 genera, 22 families and nine orders can be recognized for the entire Omo-Turkana basin. This review work clearly mentioned that transformation of hydrographic regimes and topography of Omo-River system caused by intensive dam and power plant construction may negatively affect some populations of these endemic species occurring in this basin. During the current surveys by Wakjira, (2017), 31 species in 22 genera, 17 families and 7 orders were identified from the lower Omo River and Ethiopian part of Lake Turkana, with some new records for the basin and provided an annotated checklist for native species of this basin.

2.2.5. Rift Valley Lakes Basin

The Rift Valley lakes basin is located south of Awash Basin with notable lakes which being the northern part of the East African Rift system (Giday, 2002; Bonini *et al*., 2005). The Ethiopian rifts include the southern lakes (Chamo and Abaya), the northern lakes (Hawassa, Shalla, Abijata, Langano and Zeway) and the saline northern lakes (Afambo, Gamari, Afdera, Asale and parts of Abbe) as well as the crater lakes (Lake Hora, Bishoftu, Arenguade) and Chitu (Getahun and Stiassny, 1998). However, the most fished lakes are Zeway, Langano, Hawassa, Chamo and Abaya. The major basins are as follows: the Awash River drainage in the north; two systems of linked lakes (Zeway-Langano-Abijata-Shalla and Hawasa-Shallo) and connected lotic waters in the central part of Ethiopia; lakes Abaya, Chamo and Chew Bahir and their tributaries in the south (Golubtsov *et al*., 2002).

The histories of the formation of ichthyofauna in the particular basins and the detailed data on fish’s exploration of the Ethiopian Rift Valley as well as the introduced fish species in basin has been presented by Golubtsov *et al*., (2002). According to this work, in total 31 native and four introduced fish species referable to ten families with four fish taxa that are very probably endemic to some basins within the limits of the Ethiopian Rift Valley: the cichlid genus *Danakilia,* cyprinodontid species *Lebias stiassnvae* and two cyprinid species, *Barbus ethiopicus* and *Garra makiensis* are found in the region. The fish species composition varies within the Ethiopian Rift Valley. There is a contrast between the southern part of the valley, including Abaya, Chamo, and Chew Bahir basins, and its central and northern parts. In total, 23 native fish species are found in the southern region versus 12 such species recorded from the remaining parts of the valley. The diversity of fish fauna is highest in its southern part, lowest in the central part and intermediate in the northern part. The higher species diversity in the southern basins is obviously attributed to the presence of some elements of Nilotic and East African origin (Golubtsov *et al*., (2002). Golubtsov and Mina, (2003) recorded 22-23 fish species for the Abaya Chamo-Chew Bahir system, 6-7 species for the Awasa-Shallo system, 12 species for the Zeway-Langano-Abijata Shala system, 13-15 species for the Awash system and adjacent enclosed basins. A review by Golubtsov and Darkov, (2008) listed 28-31 fish species belonging to ten families and eighteen genera for the Basin. The fish diversity in Southern Rift valley (Chamo-Abaya and Chew Bahir) basins is determined by past connections with the Omo-Turkana basin, while the latter was connected to the White Nile system seven thousand years before present. Vijverberg *et al*., (2012) reported 27 species from nine Ethiopian fresh water Lakes. According to this work, Lake Abaya and Lake Chamo were dominated by the samelarger fish species (*Synodontis schall* and *Hydrocynus forskalii*).

2.2.6. Wabishebele-Genale Basin

The Wabi Shebele and Juba system within the limits of Ethiopia includes the Wabi Shebele, Weyb, Genale and Dawa drainages. Wabi-Shebelle River starts in the Bale Mountain receiving large number of tributaries (e.g. Dawa, Genale, Gastro originates in the Ahmar) and It flows southeast into the lowlands of Somalia where it rarely (especially during seasons of heavy rain) joins the Juba River, which ultimately enters the Indian Ocean (Golubtsov *et al*., 2003; Basnyat and Gadain, 2009). According to Golubtsov and Mina, (2003), it is the only region of Ethiopia where a diadromous fish, the eel *Anguilla* species occurs.

A review by Tedla, (1973) reported 14 fish species from this Drainage system before the studies of JERBE. After works of JERBE groups, about 31 fish species belonging to 11 families and 19 genera were recorded from the Wabi-Shebelle and Juba drainage systems within the limits of Ethiopia (Golubtsov and Mina, 2003). According to these work, 33 fish species within 21 genera and 12 families were also recorded from this Basins (Golubstov and Darkov, 2008), including 10-12 endemic species to Ethiopia (Golubstov and Darkov, 2008) and 2-3 exotic species occurs in the basin (Golubtsov and Mina, 2003). Catch data in number by species have been routinely used to define fish diversity indices of inland waters (Mwangi *et al*., 2012; Galib *et al*., 2013 and Ataguba *et al*., 2014). Knowing the fishery species abundance of different water bodies can provide insight into the nature of the ecosystem (Thompson *et al*., 2015). Therefore, species richness is commonly used as an ecological indicator for ecosystem assessments (Yongfeng *et al*., 2011).

1.3. The Length weight relationships and condition factors of fish

Fish need suitable environmental conditions to live and reproduce. Individual fish species vary widely in their morphology, physiology, tolerance and response to their surroundings (Hashemi *et al*., 2015). To colonize a reservoir, a fish population must, in the first place, find conditions capable of being acted on its maintenance (basic metabolism, growth) and afterwards for its reproduction. Maintenance is limited by a number of factors, among which change in temperature regime, dissolved oxygen concentration and availability of food resources are the most important (kuriakose, 2014; Basavaraja, 2014).

Organisms could increase in size (length, weight) during development. The wellbeing of the fishes is considered as a good indicator of various water bodies' health in relation to water pollution (Kumar *et al*., 2017). The length-weight relationship indicates the wellbeing of fishes (Hamid *et al*., 2015). This is because length-weight and condition factor investigations are the cheapest means of determining the stress of water pollution on the fishes' body condition (Gupta and Tripathi, 2017). Fish can attain either isometric, negative allometric or positive allometric growth in its life (Nehemia *et al*., 2012). Isometric growth ($b=3$) is the type of growth when all the body parts grow at an approximately the same rate as the fish grows. The isometric growth pattern was reported from Lake Tana and tributaries of Blue Nile (Tesfaye, 2006; Gebremedhin *et al*., 2012; Gebremedhin and Mengist, 2014; Engdaw, 2014; Awoke *et al*., 2015). Negative allometric growth ($b<3$) is the type of growth in which fish become slender as it increases in weight. Negative patternof *Labeo barbus-intermedius* caught from Lake Langano, Gilgel Gibe reservoir and some tributaries of White Nile (Wakjira, 2013; Abera, 2016; Melaku *et al*., 2017; Temesgen, 2017) are reported. Positive allometric growth (b>3) in which fish become relatively deeper-bodied as it increases in length (Riedel *et al*., 2007) has been found in Gelgel Beles and koka reservoir population (Dadebo *et al*., 2013; Berie, 2007). The nearly isometric growth pattern in most common for this species are in both riverine and lacustrine environments.

Condition factor expresses the degree of wellbeing of fishes in their habitat. On the other hand it is a measure of various biological and ecological factors with regard to their feeding conditions (Nehemia *et al*., 2012). Food availability in the water bodies are influenced by the changes in the water chemistry due to variations in the atmosphere and the surrounding environments (Pothoven *et al*., 2001). High condition index of fish is associated with the amount of energy (fat) content, type of food available, reproductive potential and favorable environmental conditions (Paukert and Rogers, 2004). A review by Tesfahun *et al*., (2018), stated that growth pattern of fish varied in the different water bodies however, comparatively good condition factor was found in the fishes collected from Lake Ziway and Lake Langano than those observed from the rivers.

In fisheries science, the condition factor is used in order to compare the condition, fatness or wellbeing of fish (Ahmed *et al.*, 2011). It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal and Tesch, 1978). The difference in length-weight is obtained by the biotic and abiotic environmental factors of a given aquatic ecosystem which they live (Ighwela *et al*., 2011). Therefore, fish composition, diversity and the length-weight relationship of fishes under environmental conditions should be known.

2.4 **Environmental factors**

The maintenance of healthy aquatic ecosystem is dependent on the physicochemical properties and biological diversity (Venkatesharaju *et al.*, 2010). The fish community which becomes established in reservoir tends to be distinctive for each impoundment which could depend on many factors (Sarkar *et al*., 2015). According to Zhu *et al*., *(*2017), identifying the spatial pattern of fish assemblages and the correlation between fish assemblages and environmental factors is basic for conserving and managing freshwater fishes.

Each freshwater body has an individual pattern of physical and chemical characteristics which are determined largely by the climatic, geomorphological and geochemical conditions prevailing in the drainage basin. Oxygen content is a vital feature of any water body because it greatly influences the solubility of metals and is essential for all forms of biological life. The dissolved oxygen concentration depends on the physical, chemical and biochemical activities in the water body, and its measurement provides a good indication of water quality (Vijaylaxmi, *et al*., 2010; Basavaraja *et al*., 2014). According to Premlata, (2009), Changes in dissolved oxygen concentrations can be an early indication of changing conditions in the water body. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc Concentrations below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish. Temperature is an important parameter in aquatic environments as it influences many aspects of water body's physical, chemical, and biological health. Most aquatic organisms have limited optimal temperature ranges which affect survival, spawning success and metabolic rates. The temperature response for fish is highly variable among species and populations, necessitating the measurement of temperature effects on a species-by species basis (Basavaraja *et al*., 2014). A pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. Fish have maximum productivity at pH values ranging from 6.5 to 8.5. A pH value outside the range 6.5 to 8 reduces the biodiversity in a lake because it stresses the physical system of most organisms and can reduce reproduction (Ndiwa, 2011). Electrical conductivity can be used as an index of total dissolved solids and, in some cases, as a predictor of concentrations for individual ions. Conductivity shows significant correlation with ten parameters such as temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, chloride and iron concentration of water (Navneet and Sinha, 2010).

All biological production is fundamentally based on the rate of photosynthesis in water bodies. According to U.S. Geological Survey, (2018), Chlorophyll 'a' is a photosynthetic pigment found in algae and other green plants. The concentration of chlorophyll a, therefore, is commonly used as a measure of the density (biomass) of the algal population in a lake or reservoir. Chlorophyll 'a' concentrations are generally highest during summer when algal populations are highest. Moderate populations of desirable algae are important in the food chain; however, excessive populations or algal blooms are undesirable.Among the different plant pigments, chlorophyll 'a' occupies a pivotal role in primary production. The chlorophyll 'a' concentration is used as an indirect estimator of the phytoplankton biomass. Therefore, the amount of chlorophyll 'a' in water is an index of phytoplankton productivity and has been used to estimate primary productivity. The chlorophyll 'a' is the indicators of the physicochemical quality, tropic levels and the bio-productivity of dam (Mogalekar, 2017).

2.5 Conceptual framework of study

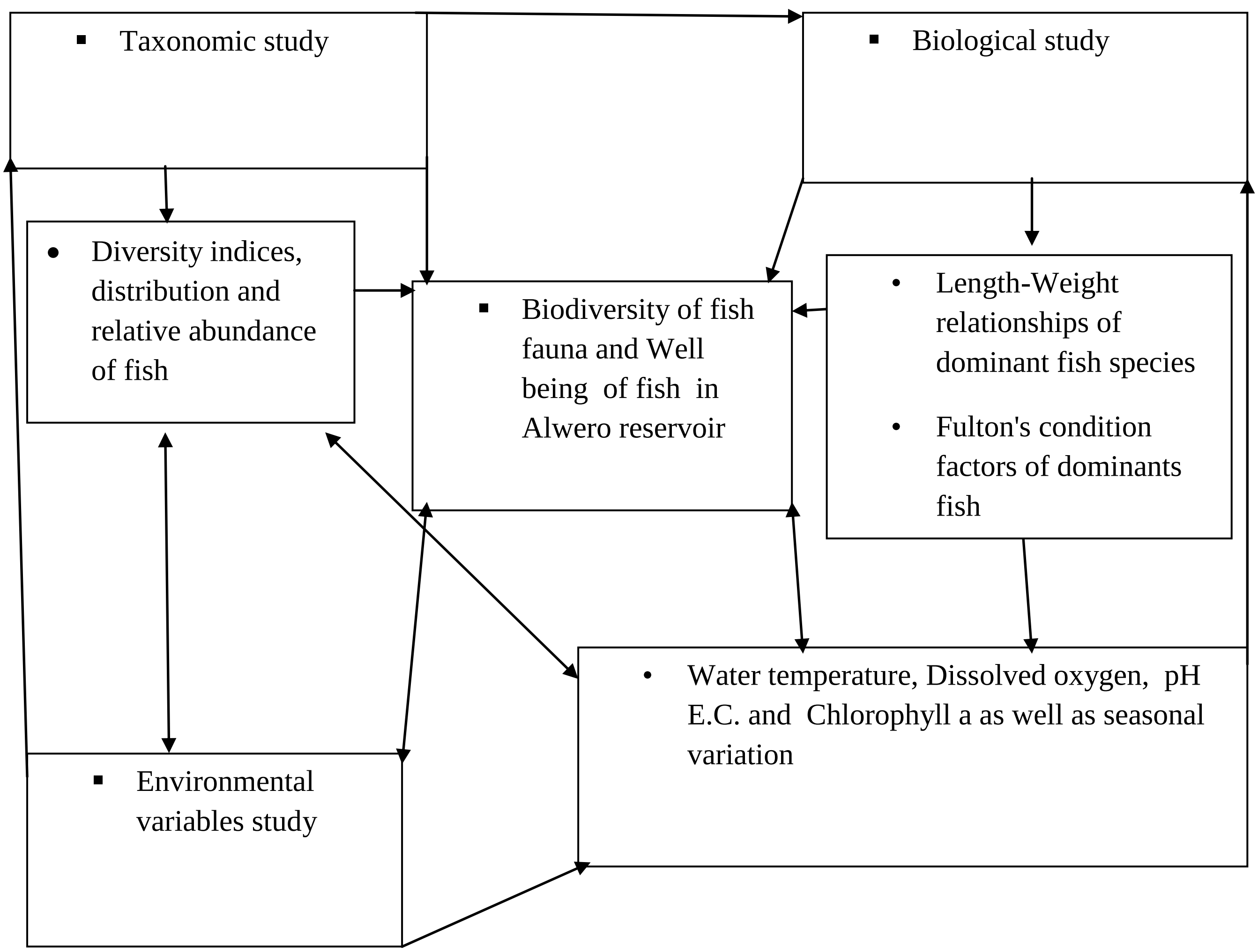


Figure.1.Flow diagram showing title of each objective that reflected to the conceptual framework of the present study

3. OBJECTIVES OF THE STUDY

3.1 General objective

The major objective of the study is to investigate species composition and diversity of fish's assemblage in the Alwero reservoir Baro Akobo river basin of Gambella region, south west part of Ethiopia.

3.2 Specific objectives

To assess species diversity of fishes in the Alwero reservoir

To identify relative abundance of fish in Alwero reservoir

To determine the length-weight relationship and condition factors of the dominant fish species in the Alwero reservoir

To investigate the relationship of fish species composition with environmental parameters (dissolved oxygen, water temperature, pH, Conductivity and Chlorophyll 'a') of the reservoir

4 METHODS AND MATERIALS

4.1 Description of the study area

Gambella region consists of three zones (Anywa, Nuer & Majang), 11 Woredas, and One special Woreda (Itang). It is at a distance of 766 km from Addis Ababa (GPNRS, 2011). The research study was conduct in Alwero Reservoir within Abobo district of Anywaa zone, Gambella National Regional State located 45Km from south of Gambella (the capital of the region) below dam near Abobo town with Altitude of 455 m and surface area of 74 km^2 (Abegaze *et al*., 2010; Tigabu, 2010; Tesfaye and wolf, 2014) where local people rely on fishing for their livelihoods in the southwestern part of Ethiopia. The construction of the Alwero river dam began in 1982 and was completed in 1997 by the government with Russian support, its purpose being to provide irrigation water for 10, 000 ha of forest land cleared and prepared for planting cash crops (mainly cotton-*Gossypium*). It was not used for over 20 years, after which the Saudi Star company acquired a permit for dam water use in that area. The construction of the dam and reservoir has had a number of unfortunate results, including the submergence of settlement and resettlement sites near the dam and Abobo town.The farm of the domestic investor, I4, is near the dam, on the other side of the road from the smaller plot of land that was later allocated to Saudi Star and used as their Nursery for seedlings (Deneke, 2013 and Molnar, 2014).

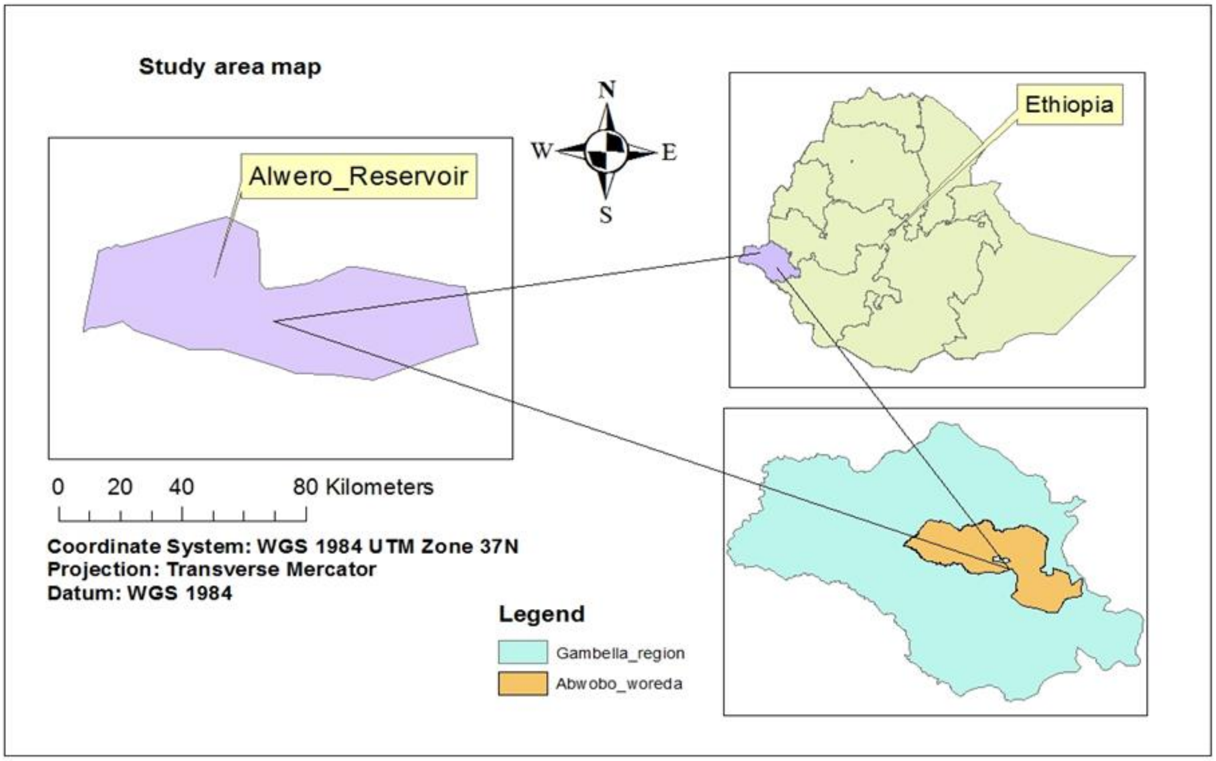


Fig.2. Map of the study Area

4.2 The Study periods and design

This study was conducted in two months one for dry season (May, 2018) and one for wet season (October, 2018) to determine the diversity of fish species and composition, some biological characteristics and information on same associated environmental characteristics of Alwero River reservoir. Comparative study design for the two designated hydrological seasons (one month of dry and one month of wet season) was employed.

4.3 Site selection

Sampling was taken at major localities known for most of the fisheries landing sites (Abegaze *et al.*, 2010). Each locality was sampled at sub sites. To obtain a full understanding of the whole Alwero-Reservoir fishery,ten sampling sites along the reservoir were selected randomly by considering prevalent of human activities such as fishing activities, accessibility and sampling safety or suitability for setting gillnets and Fyke nets. A combination of monofilament and multifilament gillnets was used for sampling fish during dry season (May 2018) and wet season (October 2018). The selection was accomplished with the help of the advisor. Site sampling was code as ALS1, ALS2, and ALS3 up to ALS10 sites. These sites are accessible throughout the year based on the information of local fishermen.

4.4 Fish sampling and identification

Collection of specimens was made at all ten sampling sites. Sample Random sampling methodology was used for selection of fisheries sites across the reservoir. Fish samples were obtained from the landings of commercial fishermen and experimental gillnets once each season (dry and wet season). Multifilament gillnets with mesh sizes 8, 10, 12 and 14 cm as well as 16 cm stretched bar mesh and a length of 25m and a depth of 1.5 m was usedand a Fyke net of 28m length was also use to catch fish alive.

Experimental gillnets were set at all sampling stations during sampling period with help of local fisherman. The gill nets were set using late in the morning (7:00 AM) and left in the reservoir for about 24 hours. Immediately after retrieval, Fishes were classified in to groups based on their Family and size, counted and their length and weight of each specimen was measured. Total length is measure to the nearest 0.1 cm using measuring board and total weight is measure to the nearest 0.1 gram respectively using electronic scale adopted from (Wakjira, 2013, 2016; Melak, 2012 and Daniel *et al*., 2017).

During fieldwork the physical and chemical features of the reservoir was recorded. In every sampling time and site, the oxygen content (mgl^{-1}) and water temperature (^oC) (using oxygen-guard oxygen meter, pH (using pH meter) and conductivity (μ $S.cm^{-1}$) (using a conductivity meter) were measured using Multimeter Specification HQ40d model and chlorophyll a wasmeasured onsite using Aquafluor Model 8000-010.

Fish specimen identification: -Fish specimens were identified to species level by using relevant taxonomic keys found in literature such as (An artificial key to fish species of the Gambella Region (the White Nile Basin in the limits of Ethiopia) and Annotated Checklist with Pictorial Identification Guide for Ethiopian fishes (Golubtsov *et al*., 1995; Habteselassie, 2012).

After taking the entire necessary information, Small specimens was labeled and preserved in plastic jars containing 10% formalin solution. The medium and large specimens were injected with 10% formalin into the abdominal cavity for total fixation. And then the collected specimens were brought to the Biological Sciences Laboratory, Department of Environmental Health Science and Technology, University of Jimma.In Laboratory study, the preserved specimen with formalin was wash thoroughly under tap water for further identification.

Species description: External morphological, morph-metric and meristic data were used in species diagnosis. Measurements were made using a digital caliper to the nearest 0.1 mm. Undamaged specimens representing different size groups was selected and measured for description of species. The principal dimensions used for describing a fish are as follows: Total length was measure from the end of the snout to end of the longest rays of the caudal fin; Fork length was measure from the tip of the snout to the end of the middle ray of the caudal fin; Standard length was measured from the tip of the snout to the origin of the central caudal rays, excluding the fin itself; Head length were measured from snout tip to posterior edge of gill cover; Depth of body was measured where depth is greatest. Caudal peduncle length was measured as the distance from the base of the last ray of the anal fin to the origin of the central caudal rays (Habteselassie, 2012; Wakjira, 2016).The number and morphology of gill rakers on the lower gill arch, barbells, and Color, the number and morphology of fin rays was also used for identification. Color is one of the most striking features of live fish, but few pigments persist after death.

4.5 Data Analysis

4.5.1 Diversity indices

Diversity indices were calculated with the aid of MS Excel and PAST® software version 3.08 as described in Hammer, (2001). Microsoft Excel 2010 was used to analyze catches data for length-weight relationships and condition factors. Abundance, richness, evenness and Shannon's index of diversity (H') were used to summarize and describe overall assemblage structure across sites. Species diversity, abundance and richness were determined by following (May 1993) and used following diversity indices;

A. Shannon diversity index (*H*') Shannon s index has a direct relationship with the species diversity, whereas index of dominance has an inverse relationship (Shannon and Weiner, 1963) and usefully for assessing the diversity of fish species for each sampling sites of the reservoir as follows:

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

Where H is Shannon Diversity Index; $\sum$ is the sum from species 1 to S; ni is the number of individuals of species "i"; N is the total number of individuals of all species; S is species richness.

B. Pielou Evenness Index "J"1966)

$J = \frac{H'}{LogN}$ Where J: Pielou evenness index, H: The observed value of Shannon index

(Hmax: lnS)

S: Total number of species

C. Index of Relative Important (Kolding, 1989)

$$\%IRI = \frac{(\%Wi+\%Ni)X\%Fi}{\sum_{j-i}^{S} (\%Wj+\%Nj)X\%Fj} X100$$

Where: %Wi and %Ni =percentage weight and number of each species in total catch

%Fi =percentage frequency of occurrence of each species in total number of sampling events

%Wj and %Nj = percentage weight and number of total species in total catch,

%Fj = percentage frequency of occurrence of total species in total number of sampling events

S =the total number of species

D. Length- weight relationship

The relationship between total length and total weight was calculated using Power regression analysis adopted from (Bagenal and Tesch, 1978) as follows:

$TW = {}_{a}TL^{b}$: Where, TW = Total weight in grams, TL = Total length in centimeters, A= intercept andB = slope of the equation, respectively.

The degree of W-Lt relationship was tested using a power regression run on the $\log^{10}$ powerized form of the data as:

Log W = Log a+ b Log Lt;

Where, Log W = Y, Log Lt = X, Log a= intercept, and b is slope of the regression line.

E. Condition factors

The well-being of fish was studied by calculating Fulton condition factor (%) (Bagenal and Tesch, 1978) as follows:

$$FCF = \frac{TW}{TL3} x100$$

Where, FCF= Fulton condition factor;

TW= Total weight in grams, and TL= Total length in cm.

4.5.2 Multivariate data analysis

Multivariate statistical analysis and regression tree models were used to analyse the Environmental factors of fish species in the sampled Alwero reservoir. Detrended Correspondence Analysis (DCA) was applied using CANOCO 4.5 (ter Braak and Smilauer, 2002) to examine whether Redundancy Analysis (RDA) or Canonical Correspondence Analysis (CCA) would be appropriate (ter Braak and Jaap, 1994) to analyse the data. The DCA yielded gradient lengths that were higher than three standard deviations, therefore CCA was used. The association between fish composition and environmental variables was analyzed using canonical correspondence analysis (CCA) in CANOCO software version 4.5. Fish abundance data were log transformed log (x+1) prior to analysis to obtain homogeneity of variance. Based on a stepwise forward selection six environmental factors were selected as independent variables. All environmental data except pH and presence of fish were log (x+1) transformed and standardized since the variables were measured in a variety of units. The statistical significance of eigenvalues and species-environment correlations generated by the CCA were tested using Monte Carlo permutations. All data (dry and wet season sampling data) were used together to construct the plots.

4. 6 Data Quality control and assurance

Assure that samples were properly labeled and preserved. Fishes from multiple collection sites were stored in a clean separate plastic jar with 10% formalin solution. Fish length and weight measured; length was measured in centimeters (mm/cm), weight in grams (g or kg) and recorded in notebook. Quality control was conducted on field procedures to ensure a high level of consistency and accuracy in all operations i.e. in situ field measurements; sample collection and field processing. Laboratory and field instruments were calibrated and standardized.

4 .7 Ethical considerations

Ethical clearance was obtained from the Department of Environmental Health Sciences & Technology; Faculty of Public Health, Institute of Health Sciences, Jimma University. Letter of support was obtained from Gambella livestock and Fishery Agency. Permission to sample in the study areas was obtained from local government administrations Abobo district.

5. RESULT

5.1 Diversity and Distribution of fishes in Alwero reservoir

Tables 1, presents the species diversity indices of the Alwero Dam during the period of study. A total of 17 species belonging to 16 genera, 13 families, and 6 orders were identified from Alwero reservoir during the present study. Among these, 12 species in 10 families and 5 orderswere identified during dry season. Five fish species belonging to 5 families and 3 Order were identified during wet season from this basin. The number of fish specimens collected, values of Shannon diversity and evenness indices of fish's species are summarized in Table 1

Parameter	**Value**
Species richness (S)	17
Abundance (N)	427
Shannon diversity index (H')	1.6
Shannon evenness index (J)	0.56

Table1. Diversity indices of fish speciesin Alwero reservoir during the present study

Table 2 presented Fish compositionand distribution of Family, Genera and Species under 6 orders. As far as the genera and families to different orders are concerned order Siluriformes consists of 5 genera under 5 families and Osteoglossiformes of 3 genera under 5 families follows by Characiformes of 3 genera under 4 families while Polypteriformes, Cypriniformes and Perciformes of single genus under single family each.Among fish Families, family Mormyridaeh as the highest number fish species with three (3) species followed by Alestiidae and Citharinidae has two (2) species each representing families respectively. Polypteridae, Osteoglossidae, Gymnarchidae, Cyprinidae, Auchenoglanidae, Bagridae, Clariidae, Mochokidae, Schilbeidae and Cichlidaehas only one (1) species representing each of the families as presented on table 2. Of the total specimens collected, 267 were caught during the dry season and 160 specimens were caught during the wet season.

Order	Family	Genus	Species	Local name (Anywaa)	Season	
					Dry	Wet
Polypteriformes	Polypteridae	Polypterus	*Polypterus senegalus*	Odweela	+	-
Osteoglossiformes	Osteoglossidae	Heterotis	*Heterotis niloticus*	Olwack	+	+
	Gymnarchidae	Gymnarchus	*Gymnarchus niloticus*	Wiyith	+	+
	Mormyridae	Mormyrus	*Mormyrus caschibe*	Adhegot dolo	+	-
		Hyperopisus	*Hyperopisus bebe*	Oboho dolo	+	-
		Mormyrops	*Mormyrops anguilloides*	Nodo dolo	+	-
Characiformes	Alestiidae	Hydrocynus	*Hydrocynus breviis*	Wheri	-	+
		Brycinus	*Brycinus macrolepidontus*	Obwohlla	+	+
	Citharinidae	Citharinus	*Citharinus citharus*	Abehl/ojahk	+	+
			Citharinus latus	Abehl/ojahk	-	+
Cypriniformes	Cyprinidae	Labeo	*Labeo horrie*	Okuura	-	+
Siluriformes	Auchenoglanididae	Auchenoglanis	*Auchenoglanis occidentalis*	Okul okook	+	-
	Bagridae	Bagrus	*Bagrus bajad*	Odwahra	-	+
	Clariidae	Clarias	*Clarias gariepinus*	Adiyo agwiyla	+	+
	Mochokidae	Synodontis	*Synodontis nigrita*	Okook	+	-
	Schilbeidae	Schilbe	*Schilbe intermedius*	Odwaho	-	+
Perciformes	Cichlidae	Oreochromis	*Oreochromis niloticus*	Orwedho	+	+

Table -2 Fish species composition and distribution of Alwero Reservoir in both seasons during the present study (+ = present; Shaded = -absent)

5.2 **Description of fish species sampled from Alwero reservoir Baro-Akobo drainage basin**

Order Polypteriformes -1family (F), 1genus (G), 1species (Spp)

Family Polypteridae-1Spp

1. *Polypterus senegalus*: Cuvier, (1829):330; Habteselassie, (2012):56; Wakjira, (2016)

Diagnosis: Dorsal fin contains 9-11 finlets

Description: Mouth terminal; Snout acuminate and jaws of equal length; interorbital region convex A pectoral fin not reaching the first dorsal ray; 9 dorsal finlets; with ganoids' scales 55-61 scales in a lateral line series; 34-40 around body in front of dorsal fin and 14-21 predorsal scales; lateral line scales simply perforated; Caudal articulated rays; pectoral fin rounded, not getting the level of the first dorsal ray; grayish body in color; TL up to 24 (in the present study)

Order Osteoglossiformes 3F, 5G, 5Spp

Family Osteoglossidae1species (Spp)

2. *Heterotis niloticus*: Cuvier, (1829):328; Tedla, (1973):21; 28; Habteselassie, (2012):59; Wakjira, (2016**)**

Diagnostic features: body scales strong and large; ventrical fin well originated behind vertical of the origin of pectoral fin

Description: Mouth terminal without barbels; adipose fins absent; It has large gill openings extending downwards; dorsal fin long, and anal fin without spine; 44 soft rays on dorsal fin and 55 soft rays on anal fin; caudal fin is rounded; TL up to 73cm (in the present study)

Family Gymnarchidae 1 species

3. *Gymnarchus niloticus*: Cuvier, (1829); Golubtsov*et al*., (1995)

Diagnostic features: Dorsal fin occupies the whole length of the body, seem to be a cylindrical rat/ snake like tail.

Description: Mouth terminal, without barbells; narrow head with pointed snout; It has no anal, caudal and pelvic fins; It dorsal fin extending the entire length of the back stopping short of naked tail without adipose fin, having dorsal fin rays up to 72, without spine; Lateral line scales at least above 200; It can grow to a least a total length of 1m (in the present study).

Family Mormyridae- 3Spp

4. *Mormyrus caschive**:*** Linnaeus, (1758):327; Habteselassie, (2012):64; Wakjira, (2016):31; Golubtsov*et al*., (1995):38

Diagnostic feature: Snout bent downward, not curved downward

Description: Snout bent downward, not as much as Mormyrus kannume does; its dorsal fin base usually originating well in advance of ventral fins base; dorsal fin more than 75 rays and 18-21 rays in anal fin; TL up to 55 (in the present study)

5. *Mormyrops anguilloides:* Linnaeus, (1758):327; Habteselassie, (2012):68; Wakjira, (2016): 31-32; Golubtsov*et al*., (1995):38; Tedla (1973):20

Diagnostic features: Anal fin slightly longer than dorsal fin, both located near the caudal fin

Description: Body elongate, mouth sub-inferior; nostrils far from each other; head is depressed, with less depth body; 25-28 (rarely 27) rays in dorsal fin; 39-42 (rarely 41) rays in anal fin; predorsal part of the body is nearly as long as preanal length; dark violet in color; TL up to 51 cm(in the present study)

6. *Hyperopisus bebe*: Lacepède, (1803): 619; Habteselassie, (2012): 66; Wakjira, (2016): 32; Golubtsov *et al*., (1995): 38;

Diagnostic features: Anal fin very much longer than the length of dorsal fin

Description: Snout is short and rounded, mouth is terminal; dorsal fin located on the rear body near caudal; dark brown in color; dorsal fin rays is more than 12, with more than 58 rays on anal fin TL 44 (present study)

Order Characiformes -2F, 3G, 4Spp

Family Alestidae-2Spp

7. *Hydrocynus brevis*: Günther, (1864); Habteselassie, (2012):

Diagnostic features: three rows of scales between the scaly process at pelvic fins and lateral line; adipose fin uniformly dark; inner edges of fork fin orange red.

Description: Conspicuous scales present; lateral stripes deep brownish; dorsal fin well originated at the vertical of pelvic fins origin; 16 rays in anal fin; 11 rays in dorsal fin; 46 scales in lateral line system; TL up to 55 cm (present study).

8. *Brycinus macrolepidotus*: Valenciennes, (1850); Golubtsov *et al*., (1995): 38; Habteselassie, (2012)

Diagnostic features: Head is much flattened above

Description: It has well originated dorsal fin behind vertical of the base of ventral

Its adipose fin is very much small; dorsal and lateral upper half including adipose and lateral lower half white; pelvic, anal, upper and lower lobe of caudal fin pinkish in color; Anal fin with at least 12-14 branched rays ; TL–27-33cm (in the present study)

Family Citharinidae -2Sp

9. *Citharinus citharus*: Geoffroy St. Hilaire, (1809); Golubtsov and Mina, (1995): 38; Habteselassie, (2012): 8; wakjira, (2016)

Diagnostic features: Anal fin is longer than dorsal fin, closer to caudal; Base of adipose fin is short nearer to the caudal fin than its distance from dorsal fin.

Description: Its body shape laterally compressed with cycloid scales on skin; dorsal and lateral upper half including adipose has dark olive color, lateral lower half white; pelvic, anal and lower lobe of caudal fin pinkish in color; Dorsal fin with 17-21 rays; anal fin with 25-31 rays; TL up to 37-52 (in the present study)

10. *Citharinus latus*: Müller and Troschel, (1845)-Golubtsov and Mina, (1995); Habteselassie, (2012)

    Diagnostic feature: base of adipose fin is longer than its distance from the dorsal fin in contrast to C, citharus; maxillaries well developed not small as the C, citharus does

    Description: body more and less elongated and moderately compressed; dorsal fin with 22 rays; anal fin with 23 rays (present study); lateral line closest to ventral fin than its distance from dorsal outline. TL 25- 52 cm (in the present study)

Order Cypriniformes - 1F, 1G, 1Sp

Family Cyprinidae -1Spp

11. *Labeo horie*: *Heckel*, (1846): 304; Golubtsov*et al*., (1995): 38; Habteselassie, (2012): 109; Wakjira, (2016).

Diagnostic features: can bedistinguished by the presence of Poor developed of labial fold in comparison to other local Labeo species

Description: 11-16 dorsal fin branched rays; its upper edge is slightly straight, with light colors prevalent in alive fish coloration; ill defined dark longitudinal lines is present run between the series scales; 40-44 scales in the lateral line; TL 44-57cm (in the present study)

Order Siluriformes -5F, 5G, 5Spp

Family Auchenoglanididae - 1 Spp

12. *Auchenoglanis occidentalis*: Valenciennes, (1840):303; Golubtsov*et al*., (1995): 38; Habteselassie, (2012): 141; Wakjira, (2016)

Diagnostic features: It has longer and pointed snout more than half of the length of headless on the body

Description: Without scales on its skin, with black spot on it body and small black spot on caudal fin; Mouth positioned inferior with yellowish spot; 3 pairs of barbels are present with short maxillary barbells not reaching the posterior edge of eye; Caudal fin shape truncate; with black spots on body, and small black spots on caudal fin; withblack spots on body, and small black spots on caudal fin; TL 34 cm (in the present study)

Family Clariidae –1Spp

13. *Clarias gariepinus*: Burchell, (1822); Golubtsov*et al*., (1995): 38; Habteselassie, (2012): 151; Wakjira, (2016).

Diagnostic features: Head is somewhat between rectangular and pointed out in dorsal outline, gill opening is wide

Description: Without scales on body; the eyes have a supero-lateral position and are relatively small; Mouth positioned sub inferior with 4 pair of barbells; dorsal fin long extending to the base of caudal fin and anal fin long extending to caudal fin; anterior edge of pectoral fin spine serrated. TL up to 74 cm (present study)

Family Bagridae -1Spp

14. *Bagrus bajad*: Forsskåll, (1775); Golubtsov*et al*., (1995): 38; Habteselassie, (2012): 142; Wakjira, (2016)

Diagnostic feature: caudal fin forked, in which both the upper and lower lobes extending into long filaments; Maxillary barbells are present reaching extremities of the ventral fin.

Description: Body elongated; no scales on the body; body relatively grayish in contrast to *B. docmak* which is pale red; dorsal I9 (usually 10) rays; its spine is slightly strong; Last ray of dorsal occupied behind vertical of inner ray of ventral; 11 rays in anal fin; its fleshy adipose fin length is long twice the base length of dorsal fin; TL 38cm (in the present study).

Family Mockokidae - 1 species

15. *Synodontis nigrita*: Valenciennes,(1840); Golubtsov *et a*l., (1995):38; Habteselassie, (2012):151

Diagnostic features: Maxillary barbels are present with a broad marginal membrane in its basal third; dorsal spine is smooth in front and serrated back, not distinctly serrated in front

Description: Its Gill opening not extending downwards beyond base of pectoral spine; adipose fin not touching rayed dorsal fin, adipose fin genuine usually not ray; It has at least more than 20 movable mandibular, the outer pair of mandibular barbels length is about twice the length of the inner pair, and both pairs have short, simple branches; the portion of the dorsal fin is made up of one strong spine and 5-7 branching rays; body color is brown or olive to blackish, with round black spots likely. The fins are grayish; caudal fin deeply forked bars; TL 34 cm (in the present study)

Family Schilbeidae -1Spp

16. *Schilbe intermedius*: Rüppell, (1832); Golubtsov*et al*.,(1995): 38; Habteselassie, (2012):151

Diagnostics features: Dorsal fin short with a spine, having 6 branched rays on dorsal fin

Description: Anal fin with 55 branched rays; four pair of barbells with maxillary barbells longer than the Schilbe uranoscopus's maxillary barbells but not much longer as Siluandon auritus does. TL 26 cm (in the resent study)

Order Perciformes-1F, 1G, 1Spp

Family Cichlidae -1Sp

17. *Oreochromis niloticus*: Linnaeus, (1758): 290-Habteselassie, (2012): 195; Wakjira, (2016)

Diagnostic features: the species has caudal with small ventrical strips; gill rackers short at least above 20 on the lower part of anterior arch. **Description**: Mouth terminal and moderately large; body compressed; a knob-like protuberance absent on dorsal surface of snout; Spinous and soft ray parts of dorsal fin continuous, with 16-17 spines and 11 to 15 soft rays; XVII-13 dorsal fin rays, and 9 anal fin rays; caudal fin truncated; dark ventrical bands on flank, and the caudal peduncle; TL 26-43 cm (in the present study)

5.3 **Relative Abundance of fish species in Alwero reservoir Baro Akobo basin**

Table 3 presents the species composition and abundance of the Alwero dam recorded during the study period. During the present study period, a total of 427 specimens were collected from ten sampling sites of Alwero reservoir Baro Akobo drainage basin. The percentage composition of the species identified at Alwero Reservoir is shown on Table 3. Fish species of the families Cichlidae *(Oreochromis niloticus*), Citharinidae (*Citharinus citharus)*, Alestiidae (*Brycinus macrolepidotus)* and Auchenoglanididae (*Achenoglanis occidentalis)* were identified as the most abundant of the dam representing 52.2%, 19.7%, 8.4% and 6.1% respectively (Table-3). *Oreochromis niloticus* was the most abundant species in term of number (233) followed by *Citharinus citharus* (84), *Brycinus macrolepidotus* (36), during both seasons and *Achenoglanis occidentalis* (26) occurred only during dry season of the total species identified. *Polypterus senegalis*, *Mormyrus caschive*, *Bagrus bajad, Schilbe intermedius* and *Hydrocynus breviis* were the least abundant fish species in number represented by onlyone specimen each (Table 3).

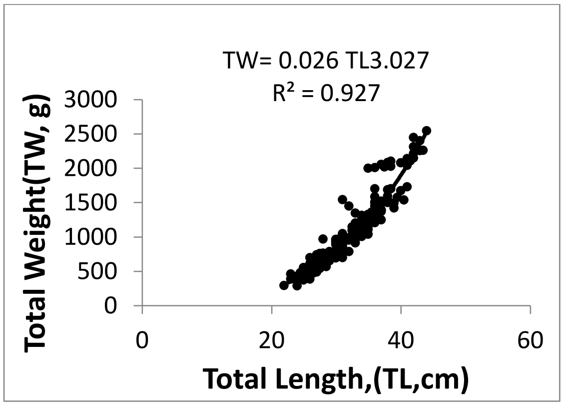
Specie	N	%N	W	%W	F	%F	IRI	%IRI
Oreochromis niloticus	223	52.22	135931.00	42.45	14	70	6627.2	63.78
Citharinus citharus	84	19.67	106436.00	33.24	9	45	2380.9	22.91
Brycinus macrolepidotus.	36	8.43	28798.00	8.99	5	25	435.6	4.19
Auchenoglanis occidentalis	26	6.09	49053.00	15.32	3	15	321.1	3.09
Clarius garipinus	10	2.34	13915.00	4.35	6	30	200.6	1.93
Heterotis niloticus	5	1.17	13100.00	4.09	4	20	105.2	1.01
Gymnarchidae niloticus	5	1.17	7850.00	2.45	4	20	72.5	0.70
Polypterus senegalis	1	0.23	250.00	0.08	1	5	1.6	0.02
Synodotis nigreta	16	3.75	11757.00	3.67	4	20	148.4	1.43
Hyperopisus bebe	3	0.70	3600.00	1.12	2	10	18.3	0.18
Mormyrops anguilloides	3	0.70	4348.00	1.36	2	10	20.6	0.20
Mormyrus caschive	1	0.23	2200.00	0.69	1	5	4.61	0.04
Citharinus latus	9	2.11	5926.00	1.85	2	10	39.6	0.38
Bagrus bajad	1	0.23	1140.00	0.36	1	5	2.9	0.03
Schilbe intermedius	1	0.23	120.00	0.04	1	5	1.4	0.01
Labeo horrie	2	0.47	2550.00	0.80	1	5	6.3	0.06
Hydrocynus breviis	1	0.23	2100.00	0.66	1	5	4.5	0.04
Total	427	100	320218	100	20	100	10391.3	100

Table-3 summary of Index of relative important (IRI) combined seasons for each fish species of Alwero reservoir

5. 4 SOME BIOLOGICAL ASPECTS OF DOMINANT FISH SPECIES

5.4.1Length-weight relationships for the most dominants of fish species in Alwero reservoir

The relationship between total length and total weight for the most dominant fish species was best described by the regression equations in terms of the line fitted to the data as shown respectively in Figs. 3, 4, 5 and 6. In growth of fishes, the regression coefficient b = 3 describes isometric growth. The value is particularly 3 if the fish retains the same shape at approximately the same rate as the fish grows during lifetime (Nehemiah *et al*., 2012). However, some fish can attains allometric growth as fish become slender as it increases in weight or become relatively deeper bodied as it increases in length (Bagenal and Tesch, 1978). From Figur-3, it describes that *Oreochromis niloticus* speciesin Alwero reservoir shows isometric growth since the weight of these fishes as increases as the same cube of their length because the b value is 3.027, *Citharinus citharus* b-value is 2.85 attains negative allowmetric growth and Brycinus *macrolepidotus* and Auchenoglanis *occidentalis* species attains positive allometric growth i.e. having b-value greater than 3(b>3) has been well described in Figs.5 and 6 as shown below.



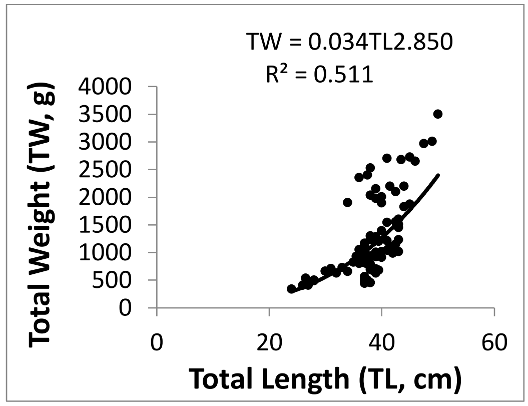
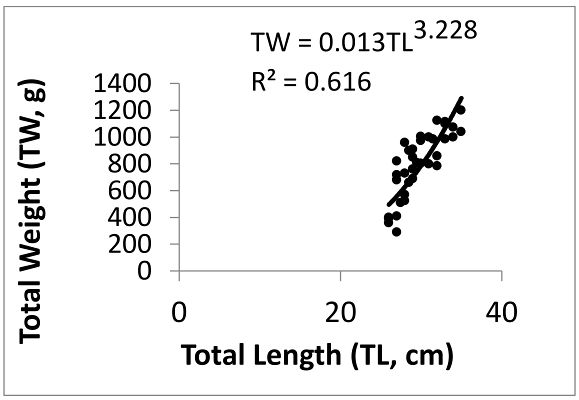


Fig-3 *Oreochromis niloticusn*

Fig 4 *Citharinus citharus*



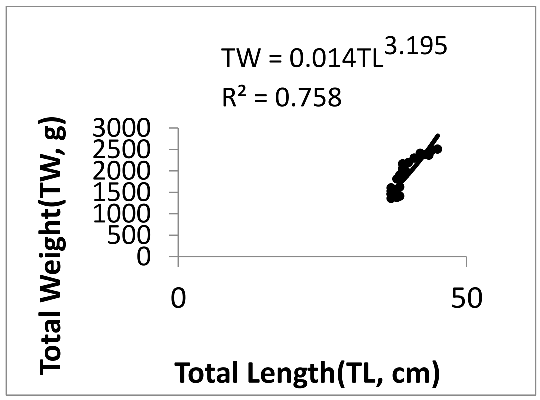


Fig-5 *Brycinus macrolepidotus*

Fig 6 *Auchenoglanis occidentalis*

5.4.2 Fulton Condition factor for the most dominant of fish species in Alwero reservoir

During the present study period, the mean values of Fulton's condition factors for the four dominants fish species (Table 5) were found in better condition in Alwero reservoir Baro Akobo basin. *Oreochromis niloticus* (3.13±0.5), *Citharinus (*2.86±0.89) *and Brycinus macrolepidotus* (3.52±0.85) respectively had higher FCF value during wet season than dry. However, high FCF value was observed for *Auchenogalis occidentalis* (3.03±0.32) in only one season (dry). The variations in condition indices for these species were statistically significant as shown on table-4 below

Fish species	Dry season		Wet season		P-value
	Mean± SD	N	Mean± SD	N	
Oreochromis niloticus	2.86± 0.278	124	3.13±0.5	99	0.000
Citharinus citharus	1.68± 0.468	50	2.86± 0.89	34	0.00
Brcinus macrolepidontus	2.54±0.617	32	3.52±0.85	4	0.012
Auchenoglanis occidentalis	3.03±0.32	26	00±00	00	0.017

Table 4 Summary of Mean± SD of Fulton' Condition Factor (FCF) for the most abundant fish species during two seasons in Alwero reservoir Baro Akobo basin (White Nile basin)

5.5 Fish Species composition and Environmental factors

5.5.1 Association between fish species and environmental factors

Seventeen fish species with six environmental factors were analyzed using canonical correspondence analysis (CCA) in CANOCO software version 4.5. The first and the second canonical axes (CCA) explained 33% and 28% of the variation in the species data, respectively. The CCA has shown that the first axis was positively correlated with the presence of fish abundance, Conductivity and dissolved oxygen as well as season. CCA ax 2 was positively correlated with chlorophyll a, pH and Temperature, and negatively with dissolved oxygen (Fig. 7). In addition, CCA analysis also revealed that *Mormyrops anguiloids, Citharinus citharus* and *Brycinus macrolepidotus* were strongly correlated with dissolved oxygen and negatively with *Polypterus senegalis*.

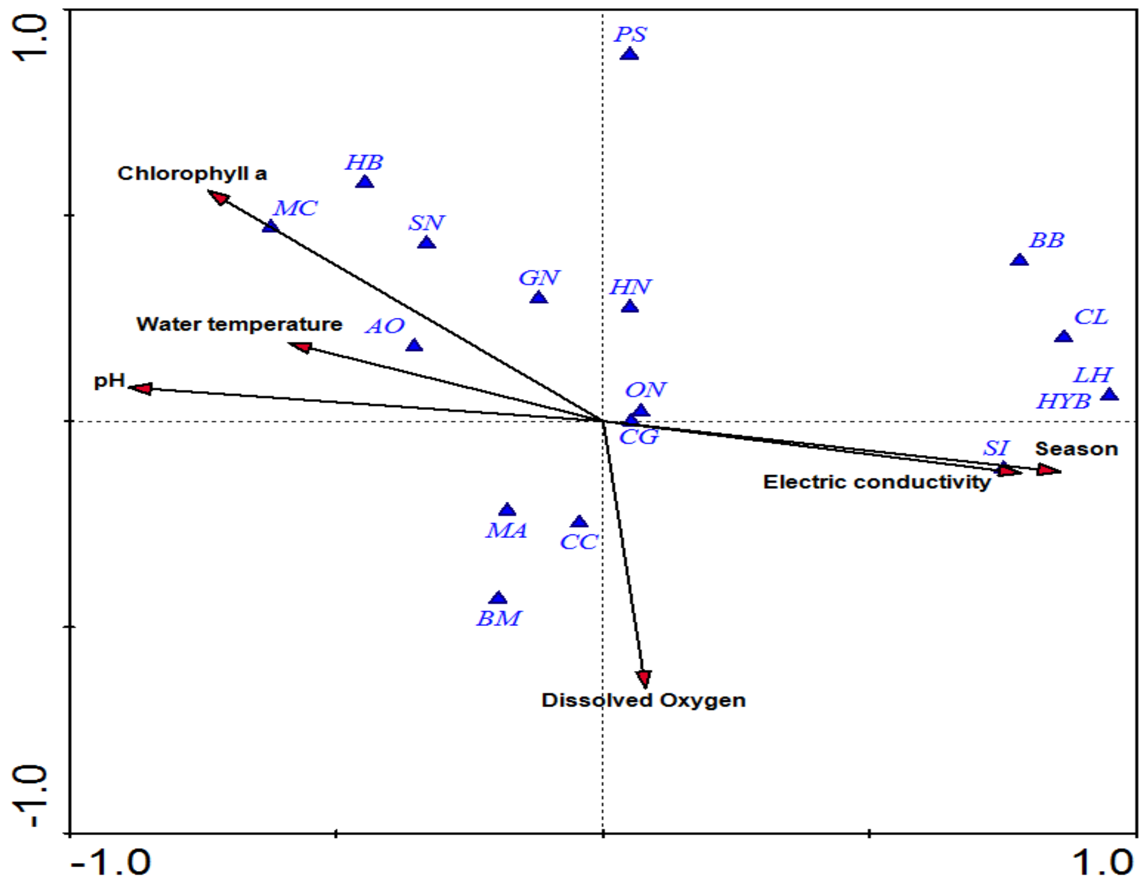


Figure 7the canonical correspondence analysis (CCA) plot for the association between fish species and environmental factors. Association between fish composition and environmental variables of Alwero reservoir PS=*Polypterus senegalus*, HN=*Heterotis niloticus*, GN=*Gymnarchus niloticus*, MC= *Mormyrus caschibe*, HB= *Hyperopisus bebe*, MA=*Mormyrops anguilloides*, HYB=*Hydrocynus breviis*, BM=*Brycinus macrolepidontus*, CC=*Citharinus citharus*, CL=*Citharinus latus*, LH=*Labeo horrie*, AO= *Auchenoglanis occidentalis*, BB=*Bagrus bajad*, CG=*Clarias gariepinus*, SN=*Synodontis nigrita*, SI=*Schilbe intermedius*, ON=*Oreochromis niloticus.*

	Axes				Total inertia
	1	2	3	4	
Eigen values	0.33	0.28	0.22	0.13	3.6
Species – environment correlations	0.88	0.87	0.87	0.78	
Cumulative percentage variance of species data	9.1	16.8	22.8	26.5	
Cumulative percentage variance of species-environment relation	31.1	57.4	78	90.3	

Table 5 Summary of Eigen value and species-environment correlations

6 DISCUSSIONS

The assessemet of fish diversity in Alwero reservoir revealed the presence of the 6 Orders, 13 Families and 17 fish species. This can be compared with ten fish species belonging to four families and three orders identified inTekeze reservoir (Teame *et al*., 2016). However, the size of Alwero reservoir covered is smaller than tekeze reservoir.

The family Mormyridae was taxonomically the most diverse group by having three genera and three species. This study further indicates that the most abundant species were *Oreochromis niloticus, Citharinus citharus, Brycinus macrolepidotus and Auchenoglanis occidentalis* respectively. The abundance of *Oreochromis niloticus* (Cichlidae) may also be linked to their high reproductive capacity (Solomon *et al*., 2017). The seasonality of fish species was distinctive during the study period in this work. The fish specimen abundance in Alwero reservoir was higher in dry than wet season (Table 2). As regard's seasonality of fish, the highest number of species was recorded duringdry (267 species) than rainy season (160 species) Appendix-3 and 4. The fish species of Alwero Lake seasonally abundance that were mostly exhibiting peaks during the dry season. This might be due to the drop in the water level and that its abundance in the dam is influenced by the seasonal change of water level. Nelson, (2006), opined out that some species such as *Auchenoglanis occidentalis* are fairly common during the dry season in swamps and rivers than in the rainy season. Thus, also this fish species occurred only during dry season among the most abundant species in the present study.There might be several reasons for variation in abundance between wet and dry seasons (Appendix-3 and 4). Variation in available nutrients and habitats, temperature, fishing effort, fish behavior, size and life history stages of fishes and others might have contributed to the variation in abundance of the catches. The reason for their abundance could be associated with seasonal fishing activity and movement of fishes. Fishing is highly seasonal in Baro-Akobo drainage basin (Abegaze *et al*., 2010). According tothis report, flooding between June and October prevents most fishermen from operating as a matter of fact; the main fishing activities season is restricted to the drier periods between October and May. Therefore, high water discharges on fish's assemblage during wet season, could cause fish disperse in the large volume of water rendering difficulty to catch them (Melak and Getahun, 2012).

The diversity of fish fauna identified from the studied reservoir contains a mixture of Nilo-Sudanic example genus *Polypterus, Heterotis, Gymnarchus, Mormyrops, Hyperopisus, Mormyrus, Hydrocynus, Brycinus, Citharinus, Labeo, Bagrus,* and East African forms genera *Oreochromis*, *Clarias*. The Nilo-Sudanic forms were the dominant forms in terms of diversity and are represented by a large number of species found in the Baro-Akobo Basin (Getahun and Stiassny, 1998). This could be probably because of the connection between the White Nile and the two rivers (Tedla, 1973; Golubtsov*et al*., 1995; Getahun and Stiassny, 1998; Golubtsov and Mina, 2003; Getahun, 2007; Golubtsov and Darkov, 2008). Similarly, the reason for the occurrences of Nilotic fishes in this reservoir are probably due to Alwero river (Baro-Akobo) basin had former connection with the White Nile. However, no endemic species was recorded in this study. Low level of endemism is probably because of the Baro Basin having connections (past and present) with the Nile and west and central African river systems and as a result, all the fish fauna represent widespread Nilo Sudanic forms (Getahun, 2007).

In terms of fish diversity approximately 17 fish species are present in consolidated form in Alwero reservoirs (Table 1) thus exhibiting rich fish species diversity. The Shannon diversity index value for the present study was within the typical value range of 1.5 to 3.5 postulated by Magurran, (2004). In the present study, Shannon diversity index value H'=1.6was recorded. This valuemight relate to both its high species richness and a highly even relative abundance (Table 1). Overall, 427 individuals of 17 species included in 6 orders and 13 families were collected during the study period. The dominant species in terms of number and percentage composition of fish species were *Oreochromis niloticus* 223 (52.2%), *Citharinus citharus* 84 (19.7%), *Brycinus macrolepidotus* 36 (8.4%) and *Auchenoglanis occidentalis* 26 (6.1%) of the total number of catches (Table3). *Polypterus senegalis*, *Mormyrus caschibe*, *Hydrocynus brevis*, *Bagrus bajad* and *Schilbe intermedius* (each represented by only one individual) were the least abundance of total catch in both seasons by number. The above finding is in agreement with that of Teamer *et al*., (2016), who reported that *Oreochromis niloticus* (51.38%) are major dominant fish species by catch in the Tekeze reservoir.

As far as the genera and families to different orders are concerned order, Order Siluriformes is the most diverse by having five families namely: Bagridae, Clariidae, Mockokidae, Auchenoglanididae and Schilbeidae followed by Order Osteoglossiformes (Osteoglossidae, Gymnarchidae and Mormyridae) and Order Characiformes (Alestidae and Citharinidae) whereas Order Polypteriformes (Polypteridae), Order Cypriniformes (Cyprinidae) Order Perciformes (Cichlidae) were the least diverse as presented on table-3. Taxonomically, family Cyprinidae is the most diverse group of the Ethiopian ichthyofauna (Golubstov and Darkov, 2008). In contrast family Mormyridae are the most diverse family in the present study in terms of specie's number. Family Alestiidae *(Hydrocynus brevis and Brycinus macrolepidotus) and Family* Citharinidae (*Citharinus citharus and Citharus latus*) represented by two genera. Family Polypteridae, Osteoglossidae, Gymnarchydae, Cyprinidae, Auchenoglanididae, Bagridae, Clariidae, Mochokidae, Schilbeidae, Cichlidaeare represented by only one species each namely: *P. senegalis, H. niloticus, G .niloticus, L. horie, Au. occidentalis, B. bajad, C. gariepinus, S. nigrita, S. intermedius* and *O. Niloticus* respectively.

The species collected from Alwero reservoir were analyzed based on Index of Relative Importance (IRI). Accordingly, the most important species in this study was *O. niloticus* (63.7%) in terms of number, weight and their frequency of occurrence in total catches, follows by *Citharinus citharus, Brycinus macrolepidotis* and *Auchenoglanis occientalis*; 22.91%, 4.19% and 3.09 % respectively (Table 3). These fish species are among the commercially important species in Gambella regional state (Abegaze *et al*., 2010). This result agreed with the observations of Melak, (2012), who reported the *Oreochromis niloticus* was the most abundant fish species in Baro-Akobo basin. However, the present observation (52.2%) was higher than results of 51.38% from Tekeze reservoir by Teamer *et al*., (2016).

The length-weight relationship (LWR) in fish is described by the power function $W= aL^b$, where W is weight, L is length where as aand b are the species-specific parameters of the function, which can be estimated by regression analysisadopted from (Bagenal and Tesch, 1978). The LWR is related to fish condition andis affected by life-history stage, nutritional state, season and area.Even after fish obtain adult body shape during their ontogeneticdevelopment, their shape may vary during growth in relation to size (positive or negative allometric growth, $b > 3$ or $b < 3$, respectively) or not (isometric growth, $b = 3$) (Nehemia *et al*., 2012). Accordingly, the length-weight relationships of the four dominant fish species in the present study shows allometric growth as indicated by the regression equation (Figures 3, 4, 5 and 6).

Fish generally passes through different stages of development which can be defined by different LWR (positive or negative allometric growth, $b > 3$ or $b < 3$, respectively), or not (isometric growth, $b = 3$) (Nehemia *et al*., 2012). Accordingly, statistical analysis of the LWR of the current study showed that the regression coefficients are indicative of Allometric growths for the most dominant fish species in Alwero reservoir where b-value is greater or less than three. The fish from the most dominant species exhibit isometric,a condition where ‘b’ value is equal to three and allowmetric growth, a condition where ‘b’ value is $>$ or $<$to three (Figures 3, 4, 5 and 6). *Oreochromis niloticus* exhibit isometric growth by having b-value (3.027) nearly equal 3, *Brycinus macrolepidotus* (b-value 3.228) and *Auchenoglanis occidentalis* (b-value 3.195) have shown positive allometric growth in Alwero reservoir. The b-value obtained for these fish species was greater than three as presented in Figures 5 and 6. While *Citharinus citharus* has shown negative allometric growth among dominant fish species, the b-value for this species was less than three as shown on Figure 4. The b-value of 3.027 was observed for *O. niloticus* in Alwero reservoir in the present study. This was varied from the values (2.76) reported by Wakjira, (2013) in Gilgel Gibe reservoir. This high condition index of fish might associated with the amount of energy (fat) content, type of food available and favorable environmental conditions in the reservoir (Paukert and Rogers, 2004).

The condition factor (K) of species in this study ranged from 1.6-3.6. The difference in condition factor value of fish specimens collected from the study reservoir may be attributed to variation in living conditions such as feeding, habitat quality, climatic condition and fish density. Thus, condition factor of the fish is strongly influenced by biotic and abiotic conditions (Egbal *et al*., 2011). Thus, condition factor is a veritable tool for assessing the health status of the aquatic ecosystem (Ighwela *et al*., 2011). The condition factor reflects, through its variations, information on the physiological state of the fish in relation to its welfare. Condition factors of population may depend on not only its age and gender composition, but also environmental elements and season of the year when samples are collected as well (Pravdin, 1966). Moreover, higher bodycondition is associated with high energy content, adequate food availability, reproductive potential and favorable environmental conditions (Paukert and Rogers, 2004). Relatively, high mean FCF value for the four most dominant fish species were recorded during wet season than dry in the present study as shown on Table 5. The condition factor of *Oreochromis niloticus* showed variations among the populations in the Ethiopian freshwater including lakes, rivers and reservoirs as noted in the report by Tesfahun, (2018). The mean FCF value for *Oreochromis niloticus* presented in this study is 3.13 comparable to 1.87 FCF value for Gilgel gibe reservoir (Wakjira, 2013). The main reason for the differences observed in the mean FCF between the presen might relate to the variation in the extent of sampling or variations in the factors such as food quantity and quality, water level and flow rate, feeding rate, health and reproductive activity of fishes in the study areas.Statistically significant seasonal variation was observed for the most four dominant species *(*Table 5). The growth patterns and FCF in *Citharinus citharus* (3.89) and *Auchenoglanis occidentalis* (3.16) were observed from other Lake in somewhere else in Nigeria (Oladipo *et al.*, 2018).

The maintenance of healthy aquatic life is dependent on the physicochemical properties and biological diversity (Venkatesharaju *et al.*, 2010). The diversity of fish species in a reservoir correlates strongly with the diversity of its habitat parameters (Kadye and Marshal, 2006). Their Maintenance might limited by a number of factors, among which change in temperature regime, dissolved oxygen concentration and availability of food resources are the most important (kuriakose, 2014; Basavaraja, 2014).

To determine whether the water quality of Alwero reservoir is good for fishing, some environmental factors (six) measurements were made. The statistical significance of eigenvalues and species-environment correlations generated by the CCA were tested using Monte Carlo permutations. Seventeen fish species and six environmental factors were analyzed in canonical correspondence analysis (CCA). In line with this, the position of a species on the CCA axis and bi plot for association was a reflection of the environmental conditions where it was found. The first axis was positively correlated with the abundance of

fish, conductivity and season as well as dissolved oxygen. Chlorophyll a, pH and temperature were negatively correlated with CCA axis 1. CCA axis 2 was positively correlated with Chlorophyll a, pH and temperature and negatively with dissolved oxygen (Fig. 7). Conductivity, dissolved oxygen and seasonwere the most important factors that explained most of the fish community for the first CCA axis 1 (Figures 7). Composition of individual fish species, which related to the environmental factors to CCA axis, was shown the first six fish species e.g. *S. nigrita*, *H. bebe*, *M .cashibe*, *C. citharus*, *G. niloticus and A.occidentali* on the CCA-2 that tended to associate with higher Chlorophyll a, pH and temperature in reservoir (Figure 7) whereas CCA-1 was associated with other species that are tolerant of water quality impairment (*Oreochromis niloticus and Clarias gariepinus*).
Dissolved oxygenconentrations were higher in the wet season samples, sugesting that runoff, precieptation turbulence increased the dissolved oxygen concentrations (Ambelu, 2009). In CCA axis analysis, there is no association (correspondance) between fish speciessuch as *P. senegalis, B, bajad, C. latus, L. horie, H. brevis* and *H. niloticus* with the present measured environmental factors. There might be other environmental fators not measured in the current study that could associate with these species. Based on the present observation, most of the physicochemical parameters of reservoir were conducive for growth of aquatic organisms. However, low concentration of DO (1.77) and presence of high pH (<9.5) were observed which are not suitable for fishing. In the present study, Chll a, pH and temperature appeared to be the most important in the structure abundance of fish species among measured environmental factors in CCA analysis.

7CONCLUSIONS AND RECOMMENDATION

7.1 CONCLUSION

This study is the first to compile data on fish diversity in the entire of reservoirs along the Alwero River. The present study revealed the presence of 13 fish families which consist of seventeen different species, with the family Mockokidea having the highest diversity of three species. The composition of the ichthyofauna of the Alwero reservoir it consists of a combination of species present in the dammed river. The fish species identified, all are native species in this study and could be documented for the Alweero (Alworo) reservoir. However there is no endemic and introducing fish species in this reservoir. As conclusion this study contributes to the knowledge of fish populations in Alwero Reservoir.

Oreochromis niloticus was the most abundant in number, andcommercially the most important fishes of the reservoir. Based on percentage composition, *Oreochromis niloticus* is relatively the most dominant fish in Alwero reservoir, which contributed to 52.2 % of the total catch.

In conclusion, Fish conditions across various size classes for Alwero reservoir implies that the lower and higher b values observed for the four most dominant species should rather be suggestive of a better condition.

Abundance of fish species in the reservoir was related to water quality of the Alwero reservoir. For instance, *Heterotis niloticus, Gymnarchus niloticus, Mormyrus caschibe, Hyperopisus bebe, Auchenoglanis occidentalis*, *Synodontis nigrita* were relatively associated with Water Temperature, pH and Chlorophyll'a' rich sites. *Mormyrops anguilloides, Brycinus macrolepidontus* and *Citharinus citharus* were found in condition relatively with Dissolved oxygen. Furthermore, the results suggest that environmental factors of the reservoir were important in the spatial structure of the fish assemblage of the Alwero Reservoir, although more specific studies are necessary needed to address these questions further.

7.2 RECOMMENDATIONS

Due to the lack of infrastructure, logistics and financial problems the present study was carried out only in Alwero reservoir-Rivers (not including their tributaries). This study was limited in time, therefore, extensive intensive study covering a wide range of Alwero River including its tributaries and all its surrounding Floodplains is recommended in order to explore and document these areas which are presumably rich in ichthyofauna.

Detailed studies on water quality need to be undertaken in order to assess the status of habitat parameters and their effect on the ichthyofaunal diversity which could contribute to the development of the country.Since some variables are negetively correlated, extra analyses on environmental factors (alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, and chloride, Phosphorous, Nitrogen, Ammonia, iron concentration of water)are nessary to give inclusive results on which parameters are the most important.

Detailed studies and assessment study are needed to be undertaken on food and feeding habits and reproductive behaviors of fish species in Alwero Reservoir and its surrounding floodplains and to suggest if the upper and lower part of Alwero river use as breeding ground for fish species in Alwero reservoir to have clear understanding on the reproductive biology of fish species.

REFERENCES

Abegaze H. Gashaw T. and Cheffo A., (2010). Fishery Development Program: Riverine Fishery Assessment in Gambella Peoples

Abera L (2016). Current status and trends of fishes and fishery of a shallow rift valley Lake, Lake Zeway, Ethiopia, and PhD Dissertation submitted to Department of Zoological Sciences, Addis Ababa University, Ethiopia, pp. 90-95.

Ambelu, B.A., 2009.Biological monitoring based on macroinvertebrates for decision support of water management in Ethiopia.PhD thesis, Ghent University, Ghent Belgium.

Assefa W (2014). Length-weight relationship, condition factor and some reproductive aspects of Nile tilapiaOreochromis niloticus in Lake Hayq, Ethiopia. *Int. J.of Zool. and Res.* (IJZR), (4)5: 47-60.

Ataguba GA, Tachia, MU, Aminu, G. Fish Species Diversity and Abundance of Gubi Dam, Bauchi State ofNigeria.*Asian Journal of Conservation Biology*. 2014; 3:60-67

Atismachew, B. Girma Taddese, Sonder K., Peden D. and Yilma Jobre, 2006. Comparative assessment of forage and livestock density in Tekeze River Basin.*Ethiop, Vet. J.* 10:25-36.

Awoke T., 2015, Fish Species Diversity in Major River Basins of Ethiopia: A Review, World Journal of Fish and Marine Sciences, 7: 365-374

Awoke T., Mingist M., and Getahun A., 2015, Some aspects of the biology of dominant fishes in blue Nile River, Ethiopia,International Journal of Fisheries and Aquatic Studies, 3(1): 62-67

Aynalem Y, Mingist M, Getu A(2018). Diversity, Relative Abundance, Species composition and some Biological Aspects of Fishes in Gilgel Abay and Andassa Rivers, Blue Nile Basin, Ethiopia. *Fish Aqua J* 9: 241.

Bagenal T.B., and Tesch F.W., 1978, Methods of Assessment of Fish Production in Fresh Waters, IBP Handbook No 3, 3rd ed. Oxford Blackwell Scientific Publication, London

Basavaraja., J. Narayana, B.R. Kiran and E.T. Puttaiah. Fish diversity and abundance in relation to water quality of Anjanapura reservoir, Karnataka India. *Int. J.Curr. Microbiol. App. Sci* (2014). 3 (3): 747-757.

Basnyat, D. and Gadain, H (2009). Hydraulic Behaviour of the Juba and Shabelle Rivers: Basic Analysis for Irrigation and Flood Management Purposes. Technical Report No W-13, FAO, Nairobi, Kenya.

Beletew, 2007.Diversity, relative abundance and biology of fishes in some Rivers and Castode parasites of African Catfish (*Clarias gariepinus*) in some Lakes of Ethiopia. MSc. Thesis, Addis Ababa University, 123pp

Berie Z., 2007, Diversity, relative abundance and biology of fishes in Beles and Gelgel Beles Rivers, Abay basin Ethiopia, MSc. Thesis, Addis Ababa University, Ethiopia, 84-85

Berra, T.M. (2001). *Freshwater Fish Distribution,* University of Chicago Press, Chicago.615p.

Bonini, M., Corti, G., Innocenti, F., Manetti, P., Mazzarini, F., Abebe, T., Pecskay, Z. (2005). Evolution of the Main Ethiopian Rift in the frame of Afar and Kenya rifts propagation.

Dadebo E., Tesfahun A., and Teklegiorgis Y., 2013, Food and feeding habits of African big barb *L. intermedius* (Rüppell, 1836) (Pisces: Cyprinidae) in Lake Koka, Ethiopia, *Journal of Agricultural Research and Development*, 3: 49-58

Daniel N.A., Steve A., & Regina E. Assessment of catch, diversity and abundance of ichthyofauna in the Tono Reservoir Northern Ghana**.** *International Journal of Fisheries and Aquatic Studies* 2017; 5 (5): 25-32

Deneke, T.T. 2013 Water Governance in Amhara Region of Ethiopia. An Institutional Analysis ShakerVerlag. Aachen 2012.

Dereje Tewabe. (2012). Spatial and temporal distributions and some biological aspects of commercially important fish species of Lake Tana, Ethiopia. The Fourth Annual Conference of the Ethiopian Fisheries and Aquatic Sciences Association (EFASA).

Engdaw F., 2014, Morphometric relations, diet composition and ontogenetic dietary shift of *Labeobarbus intermedius*(Rüppell, 1836) in Lake Tana gulf of Gorgora, Ethiopia, *International Journal of Fisheries and Aquaculture*, 6(11): 124-132

Galib S.M, A.B.M. Mohsin, S.M. Abu Naser, N. Chaki & Hassan F. 2013.Fish diversity of the River Choto Jamuna, Bangladesh present status and conservation needs.*Int. J. Biodivers. Conserv.* 5 (6), Pp.389-395.

Gebrekiros S.T (2016).Factors affecting stream fish community compositionand habitat suitability.*Journal of Aquaculture &Marine Biology*; Volume 4 Issue 2-2016 Mekelle University, Department of Biology, Mekelle, Tigray, Ethiopia.

GebremedhinS, M., Mingist A., Getahun A., and Anteneh W., 2012. Spawning migration of *Labeobarbus* spp.(Pisces: Cyprinidae) of Lake Tana Lake Tana toArno-Garno River, LakeTanaSub-basin, Ethiopia, SINET: Ethiop. J. Sci., 35(2): 95-106

Gebremedhin S., and Mingist M., 2014, Diversity and abundance of fishes in Aveya River, Blue Nile basin, Ethiopia, International Journal of Current Research, 6(5): 6466-6473

Gene S. Helfman, Bruce B. Collette, Douglas E. Facey, Brain W.Bowen (2009). The diversity of fishes: 2nd edition. Biology, Evolution and Ecology.

GPNRS, Bureau of Agriculture & Rural Development Annual Reports (2007-2010).

Getahun, A. 2007.An overview of the diversity and conservation status of the Ethiopian freshwater fish fauna. *Journal of Afrotropical Zoology, Special issue:* 87-96.

Getahun A. Freshwater eco-regions of Ethiopia. In: Theime et al. (Ed.) Freshwater eco-region of Africa: A conservation assessment. Island press, Washington D.C., USA, 2005.

Getahun and Dejen, E. (2012). Fishes of Lake Tana: A Guide Book. Addis Ababa University press, Addis Ababa, 140 pp

Getahun and Stiassny, M.L.J. (1998). The Fresh water Biodiversity crisis: the case of the Ethiopian fish fauna. SINET: Ethiop. *J.Sci*. 21(2): 207-230.

Getahun, (2003). The Nile in the Ethiopian Territory: Riverine fish and fisheries. A paper presented at the Food and Water challenge international workshop that took place in Addis Ababa, Ethiopia.

Giday W. (2002). The main Ethiopian Rift System. *In: an overview on andsedimentation processes*, C. Tudorancea, W. D. Taylor (Eds.), *Ethiopian Rift Valley Lakes*, 13-43.

Golubstov, A.S. and Redeat Habteselassie (2010). Fish faunas of the Chamo-Abaya and Chew Bahir basins in southern portion of the Ethiopian Rift Valley: origin and prospects for survival.*Aquatic Ecosystem Health and Management*, 13: 47-55.

Golubtsov,A.S.andBerendzen,P.B.(1999).Morphological evidence for the occurrence of two electriccatfish (*Malapterurus*) species in the White Nile and Omo-Turkana systems (East Africa).*Journal of Fish Biology*, 55: 492-505.

Golubtsov, A.S., Darkov, A.A., Dgebuadze, Yu.Vu.And M.V. Mina. 1995. An artificial key to fish species of the Gambella Region (the White Nile Basin in the limits of Ethiopia). Joint Ethio-Russian Biological Expedition, AddisAbaba, 84p.

Golubtsov, A.S. and K.F. Dzerjinskii. 2003. The African hill stream catfishes (Amphiliidae) of southwestern Ethiopia: the first report of the genus *Phractura* from the Nile basin *Journal of Ichthyology* 43: 151-158

Golubstov and A. Darkov, “A review of Fish Diversity in the main Drainage systems of Ethiopia,” in *Ecological and FaunisticStudies in Ethiopia*, S. Dmitry, Pavlov, Y.

Dgebuadge, A. Andrey, and M. Mina, Eds., JERBE 20 Years Scientific Cooperation, Artistic inc, Addis Ababa, Ethiopia, 2008. pp. 69-102.

Golubtsov, A.S., Dgebuadze, YuYu and Mina M.V., 2002.Fishes of the Ethiopian Rift Valley. In: Tudorancea C. and TayloW.D. (eds.) *Ethiopian Rift Valley Lakes*. Backhuys Publishers, Leiden, Holland. 167-258.

Gupta D. and Tripathi M (2017).Length-weight relationships and condition factors of five Cyprinidae species (Subfamily-Barbinae) from three diverse rivers of Uttar Pradesh, India. *Int. J.of Fish. And Aqua. Stud*.; 5(2): 594-598.

Habteselassie R. (2012). Fishes of Ethiopia.Annotated Checklist with Pictorial Identification Guide. *Ethiopian Fisheries and Aquatic Science Association,* Addis Ababa

Hamid M.A., Mansor M., and Nor S., 2015, Length-weight relationship and Condition Factor of Fish Populations in Temengor reservoir: Indication of Environmental Health, Sains Malaysiana, 44: 61-66

Hammer, Ø. Harper, D.A.T. and Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis.*Palaeontologia Electronica* 4(1): 9pp.

Hashemi SA, Ghorbani R, Kymaram F, Hossini SA, Eskandari G, et al. (2015) Fish Species Composition, Distribution and Abundance in Shadegan Wetland. Fish Aquac J 6: 128.

Hladík., J. Kubečka, T. Mrkvička, M. Čech, V. Draštík, J. Frouzová, E. Hohausová, J. Matěna, V. Matěnová M Kratochvíl1,J.Peterka, M.Prchalová1, M. Vašek. Effectsof the construction of a reservoir on the fish assemblage in an inflow river. *Czech J. Anim. Sci., 53, 2008 (12): 537–547*

International Commission on Large Dams (Icold).Historical review on Ancient Dams. Paris, France: ICOLD (2013).

Ighwela K, Ahmed A, Abol-Munafi A (2011). Condition Factor as Indicator of Growth and Feeding Intensity of Nile Tilapia Fingerlings (*Oreochromisniloticus*) feed on Different Levels of Maltose. *American-Eurasian J. Agri.Env. Sci.* 11: 559-563

Janko, M. Assefa, 2014. Fish Production, Consumption and Management in Ethiopia. *Research Journal of Agriculture and Environmental Management.* Vol. 3(9), pp. 460-466, September, 2014

Joseph R Sara, Ngoni A G Moyo, Willem J Smit, Gavin Geldenhuys, Johan Thero. An Ichthyological and Bio-monitoring Survey of Fish Assemblages in theVunduzi River from it Source on Gorongosa Mountain to its Lower Reaches inthe Gorongosa National Park, Moçambique. Aquaculture Research Unit, Faculty of Science and

Agriculture, University of Limpopo (Turfloop Campus), Sovenga, 0727, South Africa. Report: 2012.

Joint Ethio-Russian Biological Expedition (JERBE), 2007.Fish diversity in the main drainage systems of Ethiopia. Addis Ababa, Ethiopia, Poster publication.

Kumar A, Jitender KJ, and Hemendra KV (2017).Length-Weight Relationship and Relative Condition Factor of *Clarius batrachus* (Linnaeus, 1758) from GaurmatiFish Farm, Kawardha, Chhattisgarh, India.*Int. J. Curr. Microbiol*.App.Sci., 6(12): 1425-1431.

Kadye, W. T. and Marshal, B. E. (2006).Habitat diversity and fish assemblages in an African river basin (Nyagui River, Zimbabwe).*African Journal of Ecology*. 45: 374-381.

Lévêque, C., Oberdorff, T., Paugy, D., Stiassny, M. L. J. & Tedesco, P. A. Global diversity of fish (Pisces) in freshwater. Hydrobiologia 595, 545–567 (2008).

Magurran, A.E.2004. Measuring Biological Diversity.Blackwell Publishing Carlton, Victoria, Australia. 256p

May RM (1993).Patterns of species abundance and diversity. In: Cody JM (ed) Ecology and Evolution of Communities Cambridge, Mass. Harvard University Press. Solow A.R. A simple test for change in community structure.*Journal of Animal Ecol*, 62: 191-193.

Melake, T., 2010.Diversity, relative abundance and some biology of fish in Baro and Tekeze basins.MSc.Thesis, Addis Ababa University, Ethiopia

Melak and Getahun, (2012)**.**Diversity and relative abundance of fishes in some temporaryand perennial water bodies of the baro basin, Gambella, Ethiopia.The Biological Society of Ethiopia.*Ethiop. J. Biol. Sci.* 11(2):193-206, 2012

Melaku S., Getahun A., and Wakjira M., 2017. Population aspects of fishes in Geba and Sor Rivers, White Nile System in Ethiopia, East Africa. *International journal of Biodiversity*. pp. 7

Mironovskii A.N. 1994. Morphological characteristics of three species of Ctenopoma (Anabanitidae) from the White Nile basin in Ethiopia.*Journal of ichthyology*, **34**(3): 9-19.

Mogalekar H.S. 2017. Fish diversity and productivity of selected reservoirs of southern tamil Nadu.Department of fisheries biology and resource Management Fisheries college and research institute Tamil nadu fisheries university Thoothukudi- 628 008

Molnar K. (2014). Rush for the ‘blue gold’. The governance of agricultural investments influencing socio-ecological system of the Gambella region, Ethiopia

Mohammed, M (2010). Diversity Relative Abundance and Biology of Fish in Upper Head of Blue Nile River, Blue Nile Basin, Ethiopia.MSc Thesis, Bahir Dar University. Ethiopia.

Mustapha, M. K. (2008). Assessment of the water quality of Oyun Reservoir, Offa, Nigeria, using selected physico-chemical parameters. *Turkish Journal of Fisheries and AquaticSciences.* 8: 309-319.

Mwangi B.M., Ombogo M.A., Amadi J., Baker N., and Mugalu D. 2012.Fissh composition and diversityof small riverine Ecosystems in the Lakes Victoria basin, Kenya.. *International Journal of Science & Technology 2 (9): 675-680*

Navneet, Kumar, D., K. Sinha (2010). Drinking water quality management through correlation Studies among various physicochemical parameters: A case study. *International J Environ Sci.* **1**(2):253-259.

Ndiwa C. Titus, 2011. Assessment of water quality and fish producivity in three undrainable reservoirs of naromoru, nyeri county, Kenya

Nehemia A., Maganira J.D., and Rumisha C., 2012, Length-weight relationship and condition factor of tilapia species grown in marine and fresh water ponds, *Agriculture and Biology Journal of North America*, 3: 117-124

Nelson, J. Fishes of the World. Fourth Edition .John Wiley & Sons, Inc., USA New York, Canada, 2006. p344.

Nelson J.S., Grande T.C. and Wilson M.V.H., 2016.Fishes of the World, Fifth Edition.John Wiley & Sons, Inc., Hoboken, New Jersey.

Oladipo, S.O.; Nneji, L.M.; Anifowoshe, A.T.; Nneji, I.C.; Iyiola, O.A., Adeola, A.C. & Mustapha, M.K. 2018. Growth pattern and condition factor of seven freshwater fish species from Jebba Lake, north-central Nigeria. *Iranian Journal of Ichthyology*.5(2): 167-172.

Paukert C.P., and Rogers, S.R., 2004. Factors affecting condition of Flannel mouth Suckers in Colorado River, Grand Canyon, Arizona. North American J. of Fisheries Management, 24: 648-653

Paugy D., 2010a. The Ethiopian subregion fish fauna: an original patchwork with various origins. *Hydrobiologia* 649:301-315.

Paugy,D.(2010b). A historical review of African freshwater ichthyology. *Freshwater Reviews*, **3**: 1-32.

Premlata, V. (2009). Multivariant analysis of drinking water quality parameters of lake Pichhola in Udaipur, India. Biological Forum, *Biological Forum An International J,* **1**(2):97-102.

Pielou E. C. (1969). *An Introduction to Mathematical Ecology*. Jonn Wiley and Sons, New York

Plafkin JL, Barbour MT, Porter K D, Gross, SK & Hughes RM. 1989. Rapid Bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. United States Environmental Protection Agency, Washington, D. C.

Pothoven S.A., Nalepa T.F., Scheeneberger P.J., and Brandt S.B., 2001, Changes in diet and body composition of Lake White fish in southern Lake Michigan associated with changes in benthos, north. *American Journal of Fishery Management*, 21: 876-883

Ren Zhu, Qing Li, Wenjian Wang, Ling Chu & Yunzhi Yan (2017). Effects of local, river-network and catchment factors on fish assemblages in the headwater streams of the Xin'an basin, China, Journal of Freshwater Ecology, 32:1, 309-322

Riedel R., Caskey L.M., and Hurlbert S.H., 2007. Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds, Lake and Reservoir Management, 23: 528-535

Rüppell, W.P.E.S. 1829-1836. Beschreibung und abbildung mehrerer neuer Fische, im Nil entdeckt.Brönner, Frankfurt am Main 1829: 1–12.

Sarkar UK, Sharma J, Mahapatra BK (2015). A Review on the Fish Communities in the Indian Reservoirs and Enhancement of Fisheries andAquatic Environment. *J Aquac Res Development* 6: 297.

Shannon CE and Weaver W .1963.The mathematical theory of communication.University of IllinoisPress, Urbana, Illinois.

Solomn, S.G., Ayuba, V.O., Tahir, M.A, Okomoda V.T. Abundance compoosition of fish in Lake Kalgwai Jigawa State, Nigeria. *Jordan Journal of Agricultural Sciences,* Volume13, No.1 2017.

Somy kuriakose, 2014. Estimation of length-weight relationship in fishes. Fishery resources assessment division central marine fisheries research institute. Summer school on advanced Methods for fish stock Assessment and fisheries Management.Pp.**150:** 215-216

Suvarnaraksha A (2011). Biology of two keystone fish species and fish assemblage patterns andmodeling approaches in tropical river basin: Case study of PingRiver Basin, Thailand. Aquatic Ecology: 89-107.

Tadlo A. Abundance and species compositions of the fishes in blue Nile River, Ethiopia. *International Journal of Fisheries and Aquatic Studies* 2015; 2(6): 334-339

Tadlo. A.M., 2015, Fish Species Diversity in Major River Basins of Ethiopia: A Review, World Journal of Fish and Marine Sciences, 7: 365-374

Teamer T, Natarajan P, Zelealem Tesfay., Assessmentof fishery ctivities for enhanced management and improved fish production in Tekeze reservoir, Ethiopia. *International Journal of Fauna and Biological Studies* 2016; 3(1): 105-113

Tedla S. (1973). Freshwater fishes of Ethiopia. Department of Biology, Addis Ababa University.101 pp.

Teferi, Y. and Admassu, D, 2002. Length-weight relationship body condition and sex ratio of tilapia (*Oreochromis niloticus*) in Lake Chamo, Ethiopia. SINET: *Ethiop. J. Sci.*, 25:19-26.

Temesgen M., 2017. Length-weight relationship and condition factor of fishes in Lake Langena, Ethiopia, PhD dissertation, Addis Ababa University, Ethiopia, pp. 10-13

ter Braak, C.J.F., Jaap, W., 1994. On the statistical analysis of vegetation change: a wetland affected by water extraction and soil acidification. Journal of Vegetation Science 5, 361–372.

ter Braak, C.J.F., Smilauer, P., 2002. CANOCO reference manual and CanocoDraw for windows user's guide: software for canonical community ordination (version 4.5). p. 500 (Ithaca, NY, USA).

Terra B.F., A.B. dos Santos and F.G. Araújo. 2010. Fish assemblage in a dammed tropical river: an analysis along thelongitudinal and temporal gradients from river to reservoir. *Neotropical Ichthyology*, **8** (3):599-606.

Tesfahun A., Temesgen M., and Prabhadevi L., 2018, Length-weight relationship and condition factor of African big barb *Labeobarbus intermedius* (Rüppell,1836) in Ethiopian freshwater bodies:a review, *International Journal of Aquaculture*, 8(3): 17-22

Tesfaye, T.M. (2016). Diversity, Relative Abundance and Some Biological Aspects of Fishes in Genale and Awata rivers, Wabi Sheele-Genale Basin, Oromia, Ethiopia.

Tesfaye G. & M. Wolf, 2014. The state of inland fisheries in Ethiopia: a synopsis with updated estimates of potential yield. *Eco hydrology & hydrobiology 14*: 200-219.

Tesfaye G., 2006. Diversity, Relative abundance and biology of fishes in Sanja Rivers, Ethiopia, MSc thesis submitted to School of Zoological Sciences, Addis Ababa University, Ethiopia, pp. 80-84

Tessier, A. Stephane Descloux, Raymond Lae, Maud Cottet, Pierre Guedant & Jean Guillard (2016). Fish Assemblages in Large Tropical Reservoirs: Overview of Fish Population Monitoring Methods, Reviews in Fisheries Science &Aquaculture, 24:2, 160-177.

Tigabu Y, (2010). Stocking based fishery enhancement programs in Ethiopia. Ecohydrol. Hydrobiol. 10: 241-246.

Thomas J. K. & James T. P, (2007). Community indices, Parameters and Comparisons, P. 677-756

Thompson PL, Davies TJ, Gonzales A, (2015). Ecosystem functions across trophic levels are linked to functional and phylogenic diversity. PLos one 10(2)

US EPA, (2016). *National Aquatic Resource Surveys*. EPA.gov EPA Web Archive

Venkatesharaju K., Ravikumar. P., Somashekar. R. K., and Prakash. K. L., 2010. Physicochemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. Kathmandu University *Journal of Science, Engineering and Technology*, 6 (1), 50-59

U.S. Geological Survey, 2018, Lakes and reservoirs-Guidelines for study design and sampling: U.S. Geological Survey Techniques and Methods, book 9, chap. A10, 48 p. [Supersedes USGS Techniques of Water-Resources Investigations, book 9, chap. A10, version 1.0]

Vijaylaxmi C, M Rajshekhar & K Vijaykumar. 2010. Freshwater fish’s distribution and diversity status of Mullameri River, aimnor tributary of Bheema River of Gulbarga District, Karnataka. *Int J of Syst Biol*., 2: 1-9.

Vijverberg, J., E. Dejen, A. Getahun and Leopold A.J. Nagelkerke, (2012). The composition of fish communities of nine Ethiopian lakes along a north-south gradient: threats and possible solutions. Animal Biology, 62(2012): 315-335.

Vijverberg, J., Sibbing, F.A. and Eshete Dejen, (2009). Lake Tana: Source of the Blue Nile. In: Dumont, H.J. (ed.). The Nile: Origin, Environments, Limnology and Human Use. Springer Science Business Media B.V. pp.163–192.

Wakjira M. and Getahun A., 2017. Ichthyofaunal diversity of the Omo-Turkana basin, East Africa,with specific reference to fish diversity within the limits of Ethiopian waters.

Wakjira M., 2013. Feeding habits and some biological aspects of fish species in Gilgel Gibe Reservoir, Ethiopia, *International Journal of Current Research*, 5: 4124-4132.

Wakjira M., (2016). Fish and diversity, Community structure, feeding ecology& fisheries of lower Omo River &the Ethiopian part of Lake Turkana, East Africa. *Fisheries & Aquatic Science.*

World Fish Center 2004. Breeding gifts fish super Tilapia in Asia and Africa for low cost, high productivity protein. http://www.fish.org

Worthington, E.B. (1931). Cambridge expedition to the East African lakes. *Nature*, **127**: 337–338.

Worthington, E.B. (1932). Scientific results of the Cambridge expedition to the East African lakes, 1930–31. 2. Fishes other than Cichlidae. *J. Linn. Soc. (Zool)*.**38**: 121–134.

Worthington, E.B. and Richardo, C.K. (1936). Scientific results of the Cambridge expedition to the East African lakes, 1930-31. No.15. The fish of Lake Rudolf and Lake Baringo.*J.Linn.Soc.(Zool)*.**39**: 353–389.

Yerima, R., Bolorundoro, P. I., Suleiman, B. and Usman, L. U. Temporal Variation of Fish Species Composition, Abundance and Diversity in relation to Physicochemical Characteristics of Dadin Kowa Reservoir Gombe State, Nigeria. *International Journal of Applied Biological* Research 2017.

Yongfeng He. Jianwei Wang S, ithan Lek-Ang, SovanLek (2011). Predicting assemblages and species richness of endemic fishin the upper Yangtze River.

Appendix- 1 Summary of composition (N, %N), Weight (W, %W), Frequency of occurrence (F, %F) and Index of relative importan (IRI, %IRI) for each fishspecies in Alwero reservoir during dry season

Fish species	N	%N	W	%W	F	%F	IRI	%IRI
Oreochromis niloticus	124	46.44	83583	32.25	7	70	5508.54	27.54
Citharinus citharus	50	18.73	51939	20.04	5	50	1938.39	9.69
Brycinus macrolepidotus.	32	11.99	26195	10.11	3	30	662.78	3.31
Auchenoglanis occidentalis	26	9.74	49053	18.93	3	30	859.97	4.30
Clarius garipinus	5	1.87	10635	4.10	2	20	119.53	0.60
Heterotis niloticus	3	1.12	8350	3.22	2	20	86.91	0.43
Gymnarchidae niloticus	3	1.12	7250	2.80	2	20	78.42	0.39
Polypterus senegalis	1	0.37	250	0.10	1	10	4.71	0.02
Synodotis nigreta	16	5.99	11757	4.54	4	40	421.16	2.11
Hyperopisus bebe	3	1.12	3600	1.39	2	20	50.25	0.25
Mormyrops anguilloides	3	1.12	4348	1.68	2	20	56.03	0.28
Mormyrus caschive	1	0.37	2200	0.85	1	10	12.23	0.06
Citharinus latus	0	0.00	0	0.00	0	0	0.00	0.00
Bagrus bajad	0	0.00	0	0.00	0	0	0.00	0.00
Schilbe intermedius	0	0.00	0	0.00	0	0	0.00	0.00
Labeo horrie	0	0.00	0	0.00	0	0	0.00	0.00
Hydrocynus breviis	0	0.00	0	0.00	0	0	0.00	0.00
Total	267	100.00	259160	100.00	10	100	20000.00	100.00

Appendix-2 Summary of composition (N, %N), Weight (W, %W), Frequency of occurrence (F, %F) and Index of relative important (IRI, %IRI) for each fishspecies in Alwero reservoir during wet season

Fish species	N	%N	W	%W	F	%F	IRI	%IRI
Oreochromis niloticus	99	61.875	52348	36.34	7	70	6875.17	34.38
Citharinus citharus	34	21.25	54497	37.83	4	40	2363.34	11.82
Brycinus macrolepidotus.	4	2.5	2603	1.81	2	20	86.14	0.43
Auchenoglanis occidentalis	0	0	0	0.00	0	0	0.00	0.00
Clarius garipinus	5	3.125	12010	8.34	4	40	458.51	2.29
Heterotis niloticus	2	1.25	4750	3.30	2	20	90.95	0.45
Gymnarchidae niloticus	2	1.25	6000	4.17	2	20	108.31	0.54
Polypterus senegalis	0	0	0	0.00	0	0	0.00	0.00
Synodotis nigreta	0	0	0	0.00	0	0	0.00	0.00
Hyperopisus bebe	0	0	0	0.00	0	0	0.00	0.00
Mormyrops anguilloides	0	0	0	0.00	0	0	0.00	0.00
Mormyrus caschive	0	0	0	0.00	0	0	0.00	0.00
Citharinus latus	9	5.625	5926	4.11	2	20	194.78	0.97
Bagrus bajad	1	0.625	1140	0.79	1	10	14.16	0.07
Schilbe intermedius	1	0.625	120	0.08	1	10	7.08	0.04
Labeo horrie	2	1.25	2550	1.77	1	10	30.20	0.15
Hydrocynus breviis	1	0.625	2100	1.46	1	10	20.83	0.10
Total	160	100	144044	100.00	10	100	20000.00	100.00

Appendix-3 species composition, Abundance and distribution in the selected sampling site of Alwero reservoir in dry season

Species	Sampling sites										Total
	ALS1	ALS 2	ALS3	ALS4	ALS5	ALS6	ALS7	ALS8	ALS9	ALS10	
AO	4				19		3				26
CG	2		1							2	5
HN	1			2							3
GN	2			1							3
ON		6		12	35	22	25	11		13	124
CC					16	4	11	10		9	50
PS		1									1
SN			4	5	2		5				16
HB				2			1				3
MA					2	1					3
MC							1				1
BM					15				7	10	32
Total	9	7	5	22	89	27	46	21	7	34	267

Appendix-4 species composition, Abundance and distribution in the selected sampling site of Alwero reservoir in wet seasons

species	**Sampling sites**										**Total fishes**
	ALS1	**ALS2**	**ALS3**	**ALS4**	**ALS5**	**ALS6**	**ALS7**	**ALS8**	**ALS9**	**ALS10**	
CC	6			10			4			14	34
ON	21	9	19		7		10	13		20	99
CL		3								6	9
CG	1	1	1						2		5
HN				1						1	2
BB					1						1
SI						1					1
GN			1	1							2
BM	1								3		4
LH										2	2
HYB										1	1
Total	29	13	21	12	8	1	14	13	5	44	160

Appendix- 5 physicochemical parameters samplied during both seasons in Alwero reservoir

Dry season			Sampling sites							
Parameters	**ALS1**	**ALS2**	**ALS3**	**ALS4**	**ALS5**	**ALS6**	**LS7**	**ALS8**	**ALS9**	**ALS10**
DO	1.8	3.7	6.4	6.1	8.3	7.4	5.9	8.8	8.7	6.8
PH	9.8	8.5	8.0	9.0	8.5	8.0	10.0	9.5	9.0	8.9
EC	76.5	78.0	78.1	78.7	81.9	81.2	80.2	79.7	78.6	79.1
TEMP	32.2	31.9	31.6	31.2	27.5	29.1	30.0	31.1	32.0	31.0
Chll a	13.9	13.2	13.0	13.9	12.8	12.3	14.6	13.3	13.2	11.8

Wet season Parameters		Sampling sites								
DO	8.1	4.0	7.5	8.3	10.0	8.7	7.2	9.3	8.7	7.3
PH	7.9	7.7	7.6	8.7	6.2	7.0	8.5	7.5	8.5	6.5
EC	81.0	90.0	81.9	87.6	98.5	96.5	94.3	92.6	90.4	93.9
TEMP	28.7	28.9	29.2	29.8	24.0	26.4	27.8	28.0	29.8	27.00
Chll a	12.8	12.3	12.7	12.6	12.5	12.0	12.7	12.6	12.5	11.5

Appendix- 6 Morphometeric and Meristic measurement of fishes recording from Alwero

Spp.	TW	TL	SL	HL/%	HW%	HD%	SnL%	ED%	IOW%	BD%	PDL%	PFL%	CPL%	CPD%	AFBL%	DFR%	AFR%
ON	1250	26	23	30.4	88.6	50	44.3	4.3	42.8	39.1	36.9	19.6	14.8	19	60.8	57	39.1
CC	1350	37	32	25	56.25	60	15	3.2	47.5	46.8	59.4	18.8	19.4	11	20.3	59	81.3
AO	1250	37	34	29.4	62.5	37.5	75	3	50	22	14.7	22	8.8	13	7.4		
BM	504	27	23	26.9	53.2	32.3	20.2	3.2	38.7	28.3	69.6	23.9	10	12	15.2		
SN	750	34	29	27.6	60	40	50	3	43.75	24.8	15.5	27.6	5.8	8.6	10.3	17	27.6
CG	1900	74	69	17.4	55.8	75	32	1.6	41.6	14.5	67.4	11.4				70	49.3
GN	2750	91	88	19.3	35.8	64.7	27.9	0.6	20	10.5	20.5	4.4				82	
HN	3150	73	70	22.8	62.5	50	28.1	5.6	31.25	20	41.4	14.3	2.4	5.4		69	
MC	2200	55	51	25.5	42.3	46.2	52	1.5	20	27.5	41.2	15.7	37.3	5.1	8.8	151	39.2
MB	1150	44	39	25.6	72	56	35	0.5	34	25.6	100	20.5	7.7	5.1	51.3	33	159
MA	1170	51	47	27.6	36.9	76.9	26.9	1.2	16.2	18	78.7	12.6	8.5	4.7	31.9	57	87.2
PS	250	24	21	16.6	48.6	85.7	14.3	0.3	28.6	13.3	39.3	14.3	3.8	6.6	7.1	43	

Appendix-7 Morphometeric and Meristic measurement of fishes recording from Alwero reservoir during wet season

Spp.	TW	TL	SL	HL%	HW%	HD%	SnL%	ED%	IOW%	BD%	PDL%	PFL%	CPL%	CPD%	AFBL%	DFR%	AFR%
CL	350	25	19	31.6	66.6	83.3	50	3.8	41.6	100	42.1	15.3	7.7	9.3	18.3	24	27.3
BB	1200	40	35	14.8	15.3	18.3	16.3	8.5	8.8	11.8	18.8	11.8	17.8	12	15.8	13	13.8
LH	1250	44	39	11.6	17.1	16.1	44.4	3.3	50	33.3	35.9	30.7	28.2	33	33.3	41	23.1
HYB	2100	55	47	31.9	60	73.3	40	2.3	33.3	40.4	36.2	38.3	10.6	13	34	23	34
SI	120	26	20	22.5	66.6	82.2	44.4	3.3	44.4	30	10	12.5	25	15	80	30	275