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Influence of water level on fish catch efficiency in Lake Ziway, East Shoa Zone, Ethiopia

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Abstract

Lake Ziway is an economically important lake in the country. However, the physico-chemical parameters of the lake seem to be threatened by anthropogenic and climatic factors, which in turn affect biotic factors as reflected in fish catch. A study was made to assess the influence of water level on the catch efficiency of the fish in Lake Ziway. The highest rainfall was recorded during the time when temperature was low and the total annual rainfall and average temperature of the area were negatively correlated.The water level of the lake shows declining trend during the past fifteen years. Within each year the water volume fluctuates and slight rise in wet seasons then decline in dry seasons. The current irrigation practices in the upstream areas have considerably reduced the volume of the inflowing water from Meki and Ketar River and the lake itself, critically affecting the water level of Lake Ziwaythat directly related on the production of the fish. Rainfall has significant importance for the water level of the lake. Hence, the catch of the particular fish species were increased as water level increased, which in turn provides suitable spawning grounds for adults, and feeding and nursery grounds for the young. Hence, appropriate management is an urgent requirement that could assist in sustainable exploitation of the resources, so that the resource could contribute to food security in the study area in particular and in the country in general.

Keywords: Fish catch, temperature, rainfall, water level

Introduction

Lake Ziway is located in an area with many agricultural activities but very few soil conservation efforts in its catchment area. The lake has been used for a variety of development activities such as fisheries, irrigated agriculture, livestock watering, vehicle washing, domestic water supply and sanitation; and most recently, indoor flower farming, etc. Although not as pronounced as that of the nearby Lake Abijata, lake level changes were reported for Lake Ziway by Dagnachew Legesee and Tenalem Ayenew (2006) and Tenalem Ayenew and Dagnachew Legese (2007).

In addition, extreme pumping of lake water for irrigation and reduction in lake volume has resulted in soil salinity, which is evident in the irrigation fields around Lake Ziway (Derege Hailu *et al*., 1996). IBC (2005) also reported that the situation of the lake ecosystem is being affected by catchment degradation, siltation, imbalance between water inflow and outflow and uncontrolled fishing practices. Share Floriculture Enterprise one of the most visible sources of effluent, was discharging its liquid wastes into the lake; there is also discharge from the irrigated fields around the lake as well as from Meki and Ziway towns, which end up in the lake (Personal observation).

It is worth mentioning that the effects of the effluent from the discharge are very worrying, given the toxic substances Dichlorodiphenyltrichloroethanes (DDTs), hexachlorocyclohexanes (HCHs), chlordanes,and heptachlors that it may contain (Yared Tigabu., 2003). There are several evidences of some undesirable changes that have occurred in the lake, such as decline in phytoplankton biomass (Getachew Beneberu and Seyoum Mengistou, 2009), increase in dominance of toxin-producing blue-green algae such as *Microcystis* and *Cylindrospermopsis* spp. (Girma Tilahun, 2006) and imbalance between water inflow and outflow, which was mainly attributed to higher lake evaporation (Tenalem Ayenew and Dagnachew Legesse, 2007).

The water level of the lake and other factorson water quality and on food webs is complex and affects the fish production of the lake. Hence, based on the historical data available on environmental as well as water quantity, it is possible to ascribe fish production. Therefore, this study was undertaken to assess the status of fish catch in relation to some long-term environmental impacts that were recorded earlier, which will help to suggest appropriate measures that will promote the conservation and sustainable utilization of the fishery resources of the lake.

Materials and Methods

Catch

Catch and effort data were recorded from the landing sites of the lake between October 2012 and September 2014 in each district (A. T. J. Kombolcha, Dugda and Z. Dugda). Total landing by species in kg, the number and type of gears used for fishing and the number of settings for each gear were recorded. The number of gears and settings in relation to fish yield in each gear were obtained through interviews with the fishermen. From the above catch and effort data, the CpUE was computed and analyzed by using SPSS version 19 software, to examine the catch trends of the fish.

These data were also used as raising factor in the estimation of annual yield. A review was also made on the long-term trend of fish production from various published research results and unpublished data collected by Batu Fish and Other Aquatic Life Research Center.

Factors that affect the fish production

Some previous physico-chemical variables and nutrients that are directly related to the production of fishes were reviewed to assess the effects on the fish production. Monthly and yearly rainfall and temperature for the study area was obtained from National Meteorological Agency. Surface water level was measured by a standard calibrated vertical scale to referred surface level gauge located at GPS point of $07^0$55.195'N, $038^0$43.719'E and an elevation of 1639 masl.

Results

Rainfall and temperature

The fluctuation in air temperature and rainfall during the period 1982 to 2013 shown in Figure1. Lower average air temperature were recorded in 1982(19.90 ^{0}C) and in 1983 (19.95 ^{0}C) and the highest (21.8 ^{0}C) in 2002 and onwards. In contrast, the highest rainfall was recorded during the time when temperature was low, namely in 1982, which amounted to 891 mm and the lowest (364 mm) was observed in 2002. In general, the total annual rainfall and average temperature of the area were negatively correlated (Fig. 1).

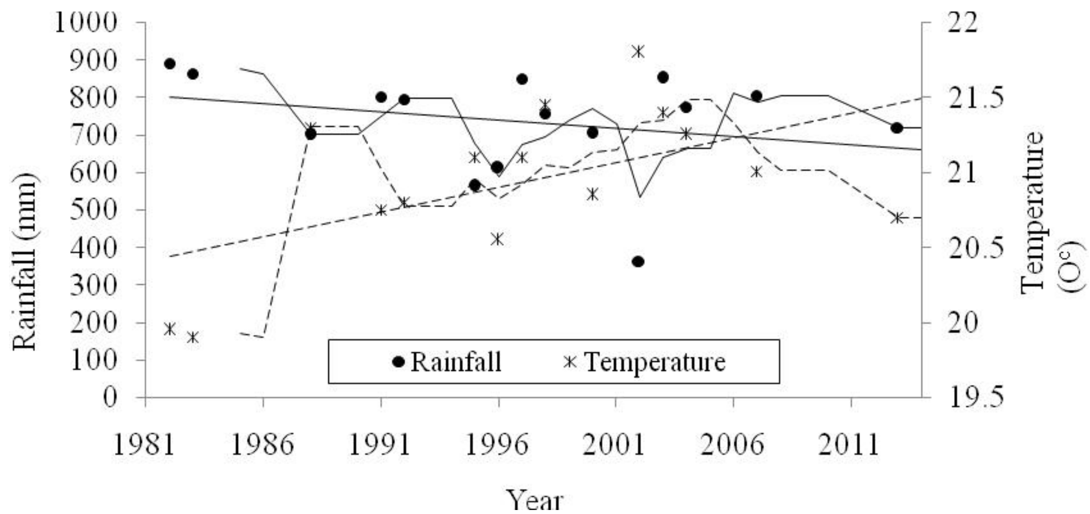


Figure 1. Total annual rainfall and average air temperature trends around Lake Ziway during the year 1982-2013(Source: National Meteorological Agency)

Like other natural resources, Lake Ziway requires a particular water level and seasonal timing of flows to guarantee the sustainability of its ecosystem and biodiversity. Hence, rainfall was the major incentive for water level of the lake and when the rain starts, the lake water was rising and the shallow shores of the lake become fringed with submerged wetlands and floating vegetation (Personal observations).

Lake water level

In this study lake water level measurement was the height at which the water fluctuates at the same spot at different time. Generally, the water level of Lake Ziway shows declining trend during the past fifteen years (Fig. 2). Within each year the water volume of Lake Ziway fluctuates following season changes with slight rise in wet seasons and decline in dry seasons (Fig. 3 and 4). During dry seasons and low rainfall years of the study period, the discharge of the feeder rivers was low, 2.23 m^3/s (Meki River) and 3.19 m^3/s (Ketar River) and as a result reduced the surface area of the lake.

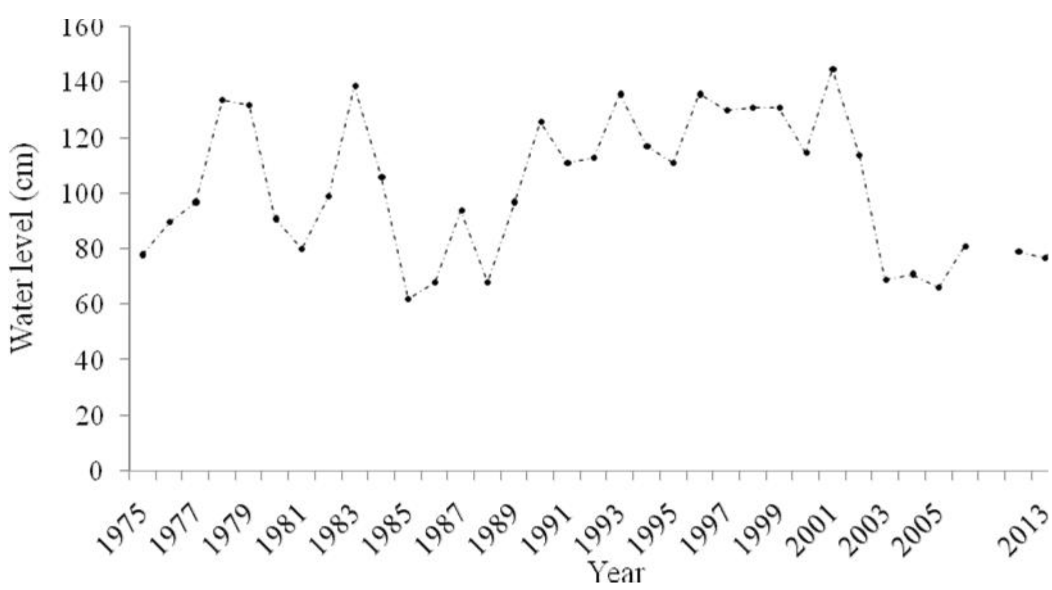


Figure 2.Mean yearly water level measurement of Lake Ziway (From1975 to 2014) (Source:Alemu Dribssa (2006) and the current study)

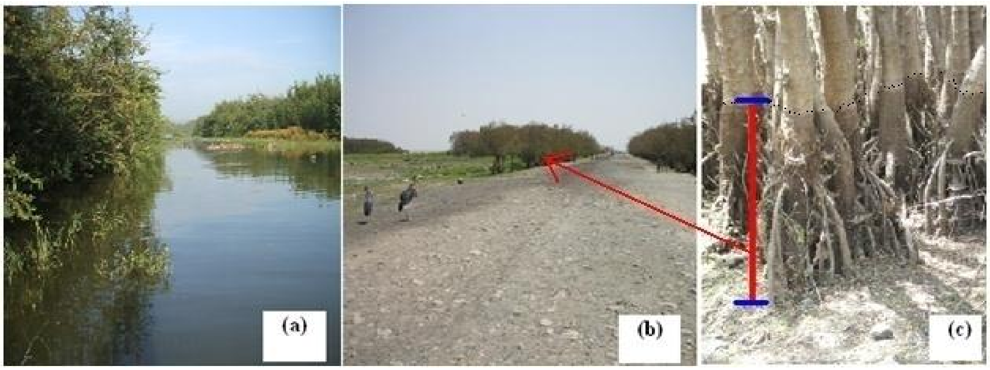


Figure 3.Lake water level fluctuations of **(a)** wet season and **(b** and **c)** dry season at the same spot during the year 2013/2014

Monthly distribution of the water level of the lake described in Figure 4. The trend shows that high water level occurred since July and reached its pick in September for the whole cycle of the years and in contrast decreased in the dry seasons (Fig. 3 and 4).

Currently, plenty of pumps are abstracting fresh water from the lake by the state, investors and private commercial farms throughout the year (Fig. 3). Even during the rainy seasons water for horticultural crops is collected from the lake. Hence, the current irrigation practices in the upstream areas have considerably reduced the volume of the inflowing water from Meki and Ketar River and the lake itself, critically affecting the water level of Lake Ziway. As a result, the lake ecosystem is being affected by catchment degradation, siltation, imbalance between water inflow and outflow.

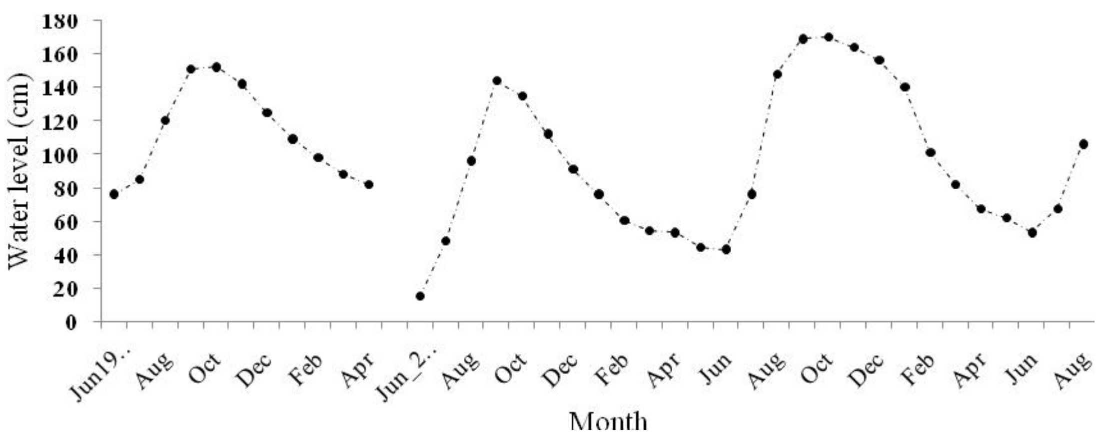


Figure 4. Mean monthly water level measurement of Lake Ziway (June 1975 - August 2014) (Source:Alemu Dribssa (2006) and the present study)

In addition, evaporation due to high temperature is one of the main factors for the decrease in the water level of the lake and the general trend described in Figure 5. The trend of temperature increase was continual, which in turn must have increased the rate of evaporation and then affect the level of the lake (Fig.5).

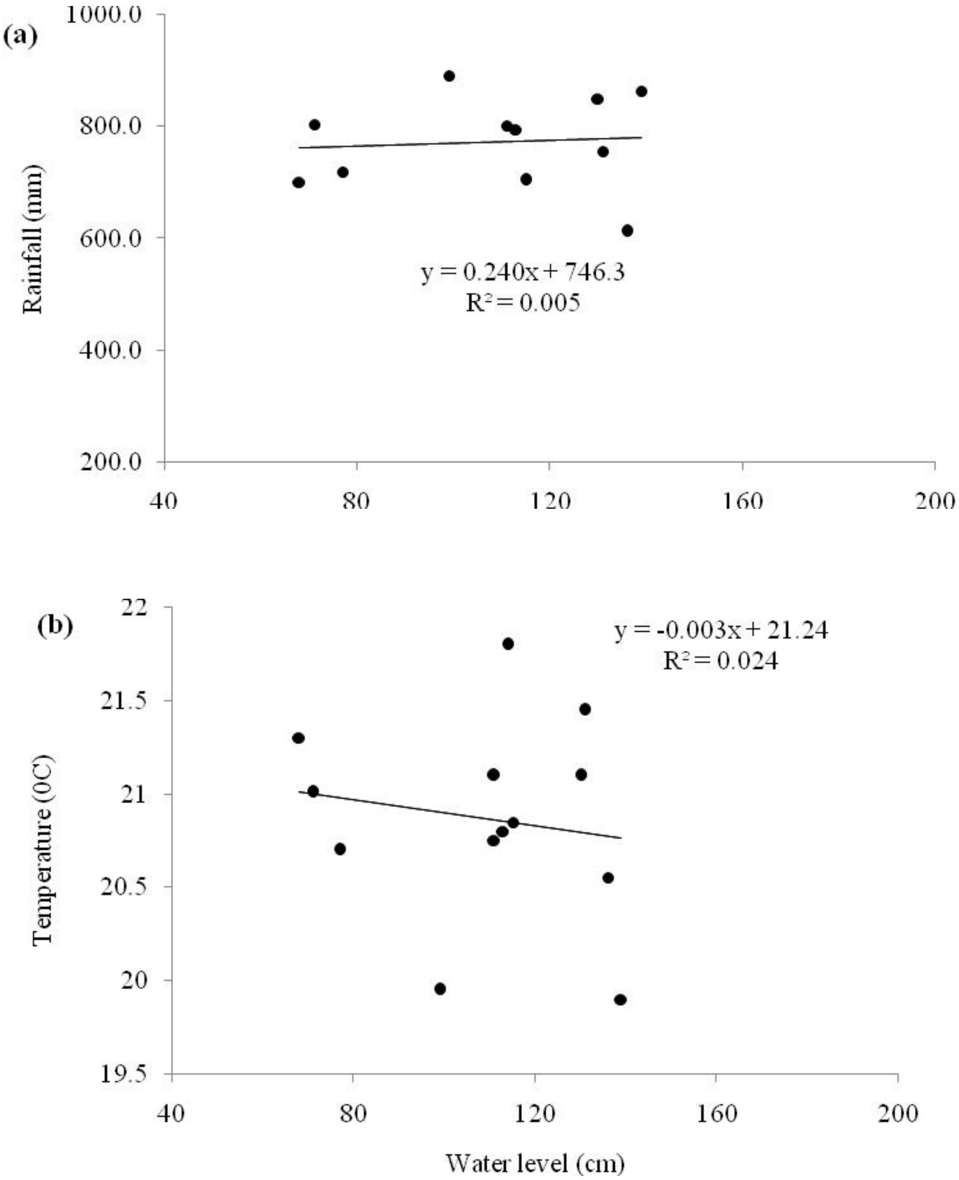


Figure 5.Relationship between water level of the lake versus(a)total rainfall and(b)temperature over the period (1982-2013) (Source:Alemu Dribssa (2006), National Meteorological Agency and the present study)

Fish catch versus water Level: Even if there were high anthropogenic pressures in Lake Ziway, abundant fish species were collected from the littoral zone of the lake. Fig.6 describes the correlations between fish catch and water level of the lake. Fishes belonging to the Family Cichilidae particularly the Nile tilapia thrives well in shallow areas with rich macrophyte vegetation cover. As indicated in Fig. 5, rainfall has significant importance for the water level of the lake. Hence, the catch of the particular fish species were increased as water level increased (Fig. 6), which in turn provides suitable spawning grounds for adults, and feeding and nursery grounds for the young.

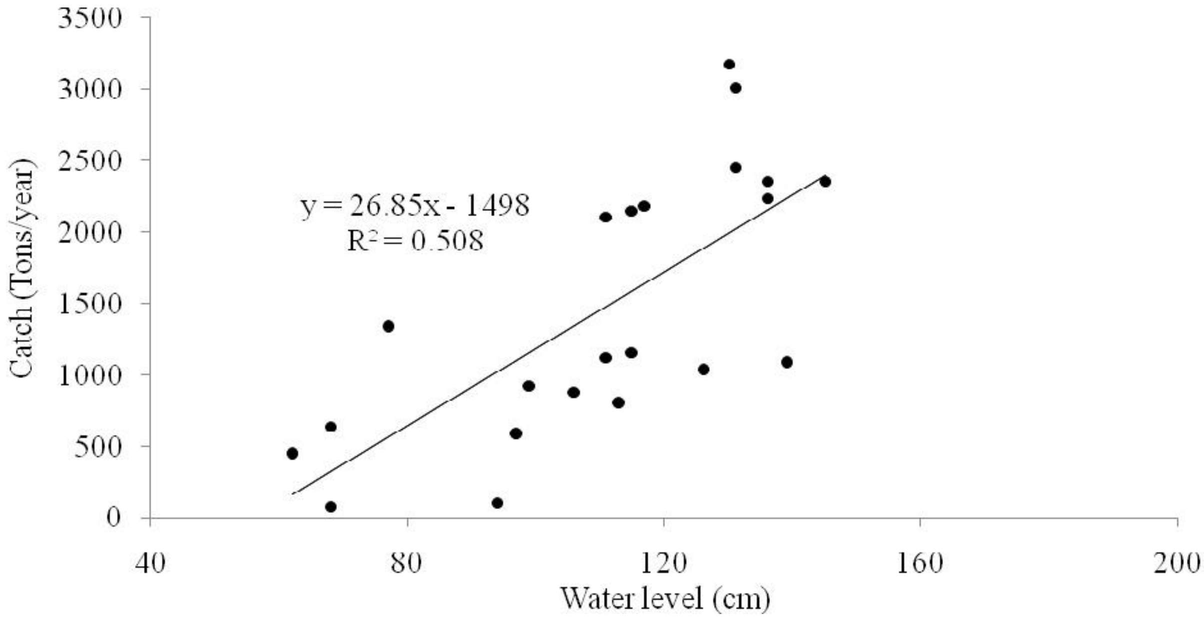
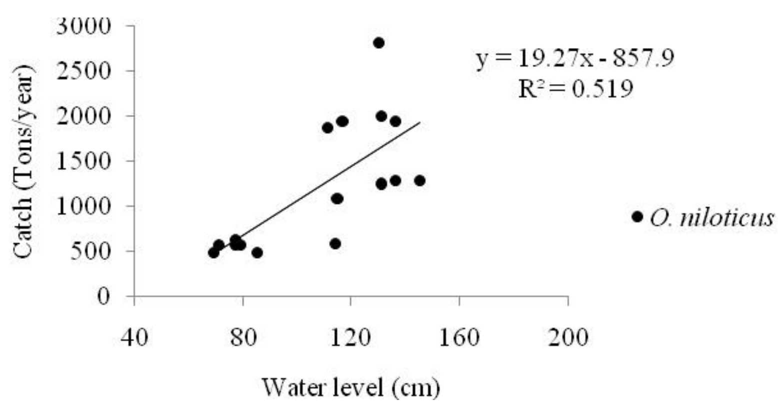
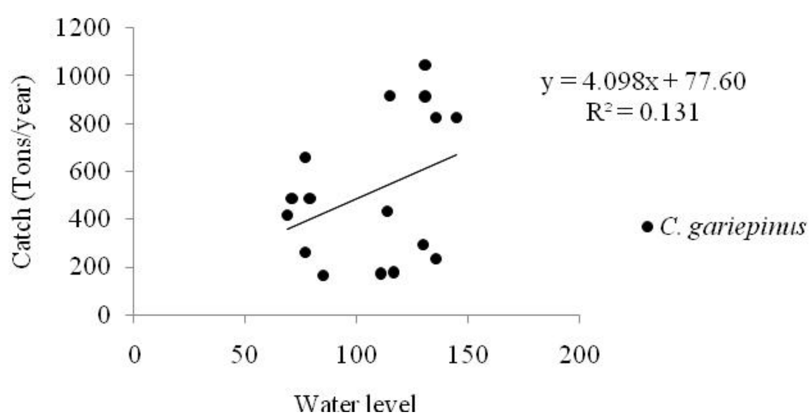


Figure 6.Relationship between water level and catch in Lake Ziway (1982-2014) (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012 and the current study)

Fig. 6 describes the relationship between fish species and water level of the lake. FamilyCichilidae was observed to be more abundant in the catch when the lake level remained high between 1993 and 2001 (Fig. 6). On the other hand currently, carp species, like *C. carpio* have dramatically increased in the catch in relation to water level decrease (Figure 6).





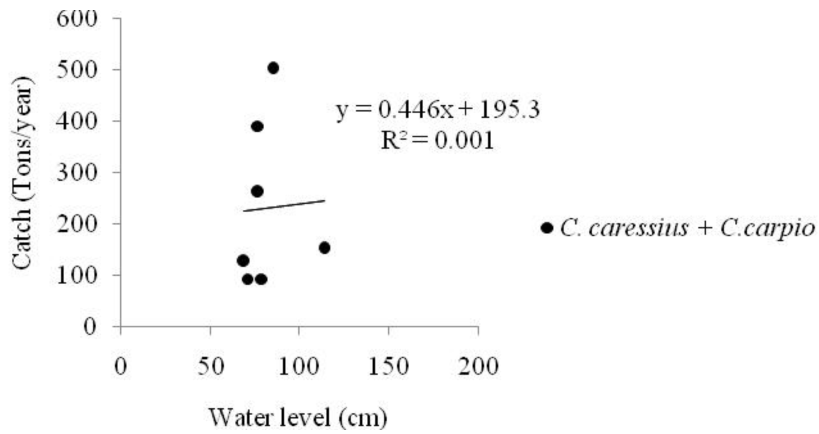


Figure 6.Catch with species and water level since 1993 (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012 and the current study)

Discussion

Rainfall and temperature

The fluctuations in rainfall, water withdrawal for irrigation, deforestation and farming activities around the study area decreasing lake water level and all have their own effect on the ecosystem of the lake. Similarly, on average the current higher air temperature, drought and reduced inflow of water had a negative impact on the ecology of the lake. Amare Mazengia (2008) has reported that the annual mean temperature around Ziway has increased over time. The variations in temperature might be as a result of climate change around the area.

In the present study, there have been instances when an increase in the total fish catch was recorded during the rains. Thus, rainfall and associated factors may act as cues for spawning by the fish so that offspring were produced at a time of better growth and survival. The role of rainfall in fish spawning was well documented (Fryer and Iles, 1972).

According to Whitfield and Harrison (2003) and Whitfield (2005), temperature has a major impact upon the richness and composition of fish in Africa. Similarly, in tropical coral reefs, the changes in fish community due to climate change effects have been reported (Parker and Dixon, 1998). Balston (2009) has shown that the long-term climate cycle may affect the life cycle stages of fishes by influencing climate variables such as rainfall, stream flow and temperature and hence nutrient availability and nursery habitat suitability in Australian waters. Spalding and Jarvis (2002) also reported that increase in temperature would have a measurable influence on the taxa of the tropical and subtropical environment.

Lake water level

Irrigated agriculture is a common practice around Lake Ziway, by pumping water from the lake and by diverting the rivers that flow into the lake. Previously water abstraction from Lake Ziway was mainly by state farms, cooperatives and/or individuals (Tenalem Ayenew and Dagnachew Legesse, 2007). The irregular rainfall variability in the lake region and the increasing population with increasing demand for water use undoubtedly increase the pressure on the lake. Recently there are different agricultural activities near the lakeshore, which solely depend on irrigation by lake water abstraction with higher efficiencies than before. The blooming floriculture in Ethiopia mainly in the study area was also a major concern. The previous irrigated state farm near the shore of Lake Ziway was currently running a large scale horticulture and floriculture greenhouse complex (current data showed that more than 100 greenhouses with an area of 400-500 ha) by a private firm that may abstract more water from the lake.

The water budget of Lake Ziway was regulated by superficial inflows and outflow, evaporation and precipitation mainly from the distant uplands as the precipitation and underground water flow in the lake area is inadequate to maintain the lake level (Alemu Dribssa, 2006). An earlier report indicates that Lake Ziway receives 0.42 and 0.44 km^3 of water via from Rivers Ketar and Meki, respectively, and losses through Bulbula River was about 0.21 km^3 and through evaporation of 0.2 km^3yr^{-1} in 100 km^2

lake area (Wood and Talling, 1988). However, a more recent estimate indicated much reduced inflows from those rivers into Lake Ziway. According to Tenalem Ayenew (2004), the annual inflows from Meki and Ketar Rivers into Lake Ziway were 264.5 and 392 million m^3, respectively. It has also been indicated that the inflow into the lake had an annual deficit of 74 million cubic meters over the overall water loss from the lake (Tenalem Ayenew, 2004).

An increasing water demand and uncontrolled water abstractions from the inflowing rivers as well as the lake for irrigation, outflow through River Bulbula, domestic use (drinking water supply to Ziway Town, watering cattle) and loss through evaporation from the lake and evapo-transpiration from the extensive vegetation which cover a greater portion of the littoral part are the major cause for the reduction. During the study period, on average, the highest precipitation was recorded in July, which lasted only for short period. Shore level fluctuations, receding in hundreds and even more meters in the fish landing sites were observed which had not recovered even after the main rainy season.

Lake Ziway was also highly dominated by emergent macrophytes, which could be due to their high tolerance for water-level fluctuation (Van Der Valk and Davis, 1976). According to Jansen *et al*. (2007), the average water level of the lake had decreased by 0.5m since 2002. One time depth measurement using eco-sounder at many points in this study indicated that the water level reduction is getting worse than the earlier reports. The maximum depth measured was 5.8 meter during this study time. The width of the lake is also shrinking. A century ago, Blundell (1906) reported that the width of the lake was about 50 miles (80.46 Km) and it had receded to 20 km by 1992 (Hughes and Hughes, 1992) and currently we could not get this width due to likehigh irrigation activities. The good example that shows the effect of different pressure in the lake is Lake Haramaya, in which the lake dried up by the year 2000. Today it has completely disappeared with grasses gradually covering the sediments (Brook Lemma, 2011).

It was also reported that there is high lake evaporation, which was estimated at 890 million m^3 annually, contributing to imbalance between water inflow and outflow (Tenalem Ayenew and Dagnachew Legesse, 2007). There was also high seasonal variation in water level, which can be attributed to seasonal rainfall and temperature (Fig. 5). According to Alemu Dribssa (2006), lake level declines from November to June and then rises from July to October. The current trend is also the same in which it declines from November to June and then rises from July to October (Fig. 4).

Relationship between yield and lake water level:

The current reduced water levels of Lake Ziway may degrade formerly productive nursing habitats of fishes and other aquatic life and reduce the resilience of ecosystems in terms of production and conservation of biodiversity. Due to relatively shortage of rainfall and increased withdrawal of water for irrigated agriculture from the Meki and Ketar Rivers and Lake Ziway over the past few years, the water level of the lake was critically lowered (Fig.5), impacting the fish reproduction as most of the breeding and nursery grounds were lost. In addition, there was an increase in population pressure continuously in the area which could greatly influence the lake. This impact can be in the form of land improvements that affect the balance between evapo-transpiration, surface runoff and groundwater recharge; and abstraction of water resulting in reduction of outflow and storage components of water balance. This also exerts impact on the fish production of the lake.

In general, the catch proportion of the fishes in the lake has declined as compared to the previous catch (LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2013). This was due to the great increase in the extent of irrigation schemes around the lake in recent years and water is being removed directly from the lakes and/or diverted from rivers that feed the lakes, organic matter accumulation from litters and siltation could further aggravate the condition (Lemma Abera *et. al*., 2014). This condition may be a threat to the lake's biota in general and the fishery in particular. Hence, this calls for serious intervention.

References

Alemu Dribessa (2006). Groundwater and Surface Water Interaction and Geo-environmental Changes in the Ziway Catchment. MSc thesis, Addis Ababa University, Addis Ababa, Ethiopia, 105 pp.

Amare Mazengia (2008). Assessment of Lake Ziway water balance. M.Sc. Thesis, School of Graduate Studies, Addis Ababa University, Addis Ababa, Pp. 128.

Balston J. (2009). An analysis of the impacts of long-term climate variability on the commercial barramundi (*Lates calcarifer*) fishery of north-east Queensland, *Australia*. *Fisheries Research,* **99**: 83-89.

Blundell H. (1906). Exploration in the Abai Basin. *The Geographical Journal,***27**: 529-551.

Brook Lemma (2011). The impact of climate change and population increase on Lakes Haramaya and Hora-Kilole, Ethiopia (1986-2006). In: *Impacts of climate change and population on tropical aquatic resources*, proceedings of the Third International Conference of the Ethiopian Fisheries and Aquatic Sciences Association (EFASA), Addis Ababa. Pp. 9-32.

Dagnachew Legesse and Tenalem Ayenew (2006). Effects of improper water and land resource utilization on the central Main Ethiopian Rift lakes. *Quaternary International,* **148**:8-18.

Derege Hailu, Hess, M. and Tenalem Ayenew (1996). The problem of high rise ground water in Amibara Irrigation Project, Middle Awash Basin. Ethiopian Science and Technology Commision, Unpublished report, Addis Ababa, Ethiopia.

Felegeselam Yohanes (2003). *Management of Lake Ziway fisheries in Ethiopia*. M.Sc Thesis, University of Toromso, 60 pp.

Fryer G. and Iles T. (1972). *The Cichlid Fishes of the Great Lakes of Africa: Their Biology and Evolution*. Oliver and Boyd, Edinburgh. pp. 6-72.

Getachew Beneberu and Seyoum Mengistou (2009). Oligotrophication trend in Lake Ziway, Ethiopia. *SINET Ethiop. J. Sci*., **32**:141-148.

Girma Tilahun (2006). Seasonal variation in species composition, abundance, size fractionated biomass and primary production of phytoplankton in lakes Ziway, Awassa and Chamo. PhD. Dissertation, Addis Ababa, Ethiopia, 200 pp.

Hughes R. and Hughes J. (1992). *A Directory of African Wetlands*. IUCN Gland, Cambridge, UK, 820 pp.

IBC (Institute of Biodiversity and Conservation) (2005). *Site Action Plan For The Conservation and Sustainable Use of Lake Ziway Biodiversity (Rift Valley Lakes Project)*. Institute of Biodiversity, Addis Ababa, Ethiopia, 76 pp.

Jansen H., Hengsdijk H., Dagnachew Legesse, Tenalem Ayenew, Hellegers, P. and Spliethoff P. (2007). *Land and water resources assessment in Ethiopian Central Rift Valley*. Wageningen UR, The Netherlands, 83pp.

Lemma Abera, Abebe Getahun and Brook Lemma (2014). Composition of commercially important fish species and some perspectives into the biology of the African Catfish *Clarias gariepinus* (Burchell), Lake Ziway, Ethiopia. *International Journal of Advanced Research,* **2**: 864-871.

Mathewos Hailu (2013). Reproductive aspects of common carp (*Cyprinus carpio* L, 1758) in a tropical reservoir (Amerti: Ethiopia). *Journal of Environmental Microbiology,* **1**: 114-118.

Parker R. and Dixon R. (1998). Changes in a North Carolina reef fish community after 15 years of intense fishing global warming implications. *Transactions American Fisheries Society,* **127**: 908-920.

Spalding M. and Jarvis G. (2002). The impact of the 1998 coral mortality on reef fish communities in the Seychelles. *Marine Pollution Bulletin,* **44**: 309-321.

Tenalem Ayenew (2004) Environmental implications of changes in the levels of lakes in the Ethiopian Rift since 1970. *Regional Environmental Changes*, **4:**192-204.

Tenalem Ayenew and Dagnachew Legesse (2007). The changing face of the Ethiopian rift lakes and their environs: call of the time. *Lakes & Reservoirs: Research and Management,* **12**: 149-165.

Van Der Valk A. and Davis C. (1976). Changes in the composition, structure and production of plant communities along a perturbed wetland coenocline. *Vegetation,* **32**:87-96.

Whitfield, A. (2005). Fishes and freshwater in southern African estuaries - a review. *Aquatic Living Resources,* **18**: 275-289.

Whitfield, A. and Harrison T. (2003). River flow and fish abundance in a South African estuary. *Journal of Fish Biology,* **62**: 1467-1472.

Wood R. and Talling J. (1988). Chemical and algal relationships in a salinity series of Ethiopian waters. *Hydrobiologia*, **158**: 29-67.

Yared Tigabu (2003). The current status of Lake Ziway. In: *Wetlands and Aquatic Resources of Ethiopia: Status, Challenges and Prospects*. Proceeding of the workshop organized by Biological Society of Ethiopia, Addis Ababa, Ethiopia. Pp. 1-10.

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