Impacts of Anthropogenic Activities on Fish Diversity of the Ethiopian Rift Valley Lakes: A Review

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Abstract

Ethiopia, being a landlocked country since 1993, is fortunate in being blessed with a number of inland water bodies, such as, lakes, rivers, reservoirs, ponds and wetlands including marshes, floodplain and swamps. These aquatic habitats provide many socio-economic and a wide range of ecological services. The Ethiopian Rift Valley is part of the Great East African Rift Valley and its floor contains many lakes which are home for about 30 different fish species. The Rift Valley is also the region where relatively many alien fish species were introduced. Some of the Rift Valley lakes are used for commercial fisheries, irrigation, recreation, renewable energy supplies and for some industrial purposes. However, many anthropogenic activities like deforestation, habitat destruction, poor soil and water conservation practices, pollution by organic and inorganic chemicals from different sources, introduction of alien species and over fishing are considered as the major challenges of the area. These activities are directly or indirectly affect the water quality and quantity of the lakes, as well as, water supplying rivers and thereby threatening the fish diversity. Therefore, executing environmental impact assessment before approving any investment projects, and enforcing industries to have waste treatment plants (like constructed wetlands) as integral part of the production system, and developing and encouraging ecotourism activities should be taken as an intervention measures to sustain the ecological and socioeconomic benefit of the resource for both the present and future generations.

Key words: Ecological services, ecotourism, Ethiopia, constructed wetlands, pollution

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1. INTRODUCTION

Water is the basic element of the life support system of the planet and a constituent of both plant and animal tissues. It mediates global scale ecosystem processes linking atmosphere, lithosphere and biosphere by moving substances between them and enables chemical reactions to occur. The total global water resources constitute approximately 1.385 billion km^3 which covers about 70% of the earth's surface (Shiklomanov and Rodda, 2003). However, only 2.5% of the global water resources are fresh; the rest (97.5%) being saline. Of the worlds fresh water as little as 0.3% is actually available as fresh water habitat (Abebe Getahun and Stiassny, 1998).

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Fresh water ecosystem comprises lakes, rivers, reservoirs and wetlands including marshes, flood plains and swamps. These aquatic habitats provide us with harvestable plants and animals, travel and transportation routes, renewable energy supplies and a wide range of ecological services in particular waste removal and water purification. The discrete and often patchy nature of fresh water habitats results in a higher degree of isolation than marine environments and this has apparently resulted in a greater genetic divergence and speciation of organisms (Abebe Getahun and Stiassny, 1998). Surprisingly enough, it is in this tiny 0.01% of the earth's total water that harbor about one-quarter of all vertebrate biodiversity (i.e. fresh water fishes) is concentrated (Stiassny and Raminosoa, 1994; Stiassny, 1996). However, freshwater systems that contain the diverse communities of species are under stress. It has lost a greater proportion of their species and habitat than ecosystems on land or in the oceans, and they face increasing threats by many anthropogenic activities. One evidence is the IUCN (1994; 1996) Red book listings in which most (about 84%) of the threatened species are fresh water species.

Ethiopia is gifted with a variety of aquatic ecosystems such as a number of lakes, large and medium perennial rivers, streams, reservoirs and wetlands that are of great scientific and economic importance. The total surface area of inland water bodies in Ethiopia is 8,800 square kilometers (Greboval et.al., 1994). These water bodies are home for about 183 fish species (Golubtsov and Mina, 2003).

There are a number of inland water bodies in the Ethiopian Rift Valley. The Ethiopian Rift Valley is part of the Afro-Arabian Rift system, bounded by the Arabian plate to the north and the African plate to the west and east. It is a system of down faulted troughs starting from the Jordan-Dead Sea Rift, the Red sea, and the Gulf of Aden and continues south wards through East Africa Rift to Mozambique (Tudorancea and Taylor, 2002 and New world encyclopedia[2]). The Great East African Rift Valley splits the high lands of Ethiopia into western and eastern halves, and the Ethiopian Rift Valley lakes occupy the floor of the Rift Valley between the two highlands (Fig.1).

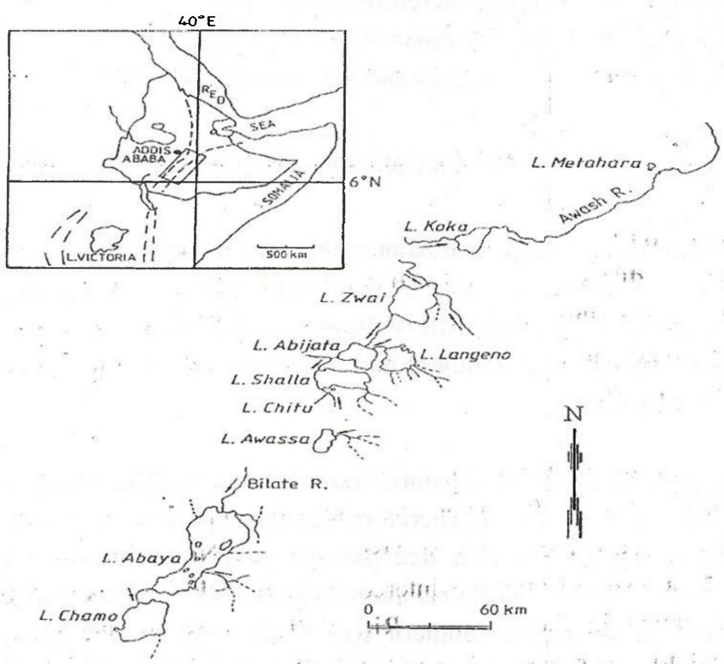

Fig. 1 Location and drainage patterns of lakes in the Ethiopian Rift Valley (Elizabeth Kebede *et al.*, 1994)

[2]Great Rift Valley: http://www.newworldencyclopedia.org/entry/Great_Rift_Valley; Retrieved January 27, 2011

The Ethiopian Rift Valley lakes are the northern most of the African Rift Valley lakes. The lakes that are found in Ethiopian Rift Valley include the southern lakes (Abaya, Chamo, Chew Bahr (formerly called Stephanie) and small portion of Turkana), the central lakes (Awassa, Shala, Abijata, Langano, Ziway and manmade Lake Koka) and the saline Northern lakes (Beseka, Afdera, Asale and Abbe). There are also crater lakes such as the high plateau Bishoftu group (Lake Hora, Arenguadie, Bishoftu, Kilole and Pawlo) and Lake Chitu in the Rift Valley.

According to Zinabu G/Mariam (2002) most of the Ethiopian Rift Valley lakes are productive, containing indigenous population of edible fish and supporting a variety of aquatic and terrestrial wild life. Some of these lakes are being used for commercial fisheries, irrigation, recreation, and some industrial purposes. Although there is increasing usage of these lakes, they are not yet permanently damaged and depleted as some other water bodies in the developing countries. However, there seems to be little awareness of the risks of fish diversity crisis via different anthropogenic activities. Therefore, the purpose of this paper is to highlight and discuss how much the Ethiopian Rift Valley lakes fish diversity are threatened by different anthropogenic factors and recommend some intervention measures.

2. FISH FAUNA OF RIFT VALLEY LAKES

According to Golubtsov and Mina (2003) the Ethiopian Rift Valley lakes are home for about 30 different species of fish fauna (Table 1). However, the distribution of fish diversity within the Rift Valley is extremely uneven. The diversity of fish fauna is highest in its southern part, lowest in the central part and intermediate in the northern part.

In the past, lakes Abaya, Chamo, Chew Bahr and Turkana were linked to the White Nile (Grove et al, 1975). Therefore, the fish fauna of these lakes are the same as Sudanian species due to a free passage of the Nile fauna to the lakes (Beadle, 1981). As a result of previous interconnection of these lakes with the Nile system, the fish fauna in the southern Rift Valley lakes are the most diversified as compared to other parts of the Rift Valley and is composed of more than 20 species. Out of these species *Lates niloticus, Oreochromis niloticus, Labio horii, Bagrus docmac, Clarias gariepinus and Barbus* species are of great economic importance to the lake fishery industry (LFDP, 1996).

Fish species inhabiting Lake Awasa are *O. niloticus, Clarias gariepinus, Barbus spp, B. amphigramma, Garra* species *and Aplocheilichthys* species (Demeke Admasu and Elias Dadibo, 1997). Grove *et al* (1975) states that Lake Ziway, Langano, Abijata and Shala were one single lake and was called Galla lake 5000 years BP. A period of extensive faulting and volcanic activity followed during late Pleistocene which led to a configuration of these lakes similar to the present form. As a result the fish fauna inhabiting these lakes are more or less the same. However, there are some endemic species which is found only in one lake but not in the other. A good example is *Barbus ethiopicus* from lake Ziway and Awash (a river which flows to the Rift Valley lakes) basin. This fish species is one of the endemic and most threatened fish species in Ethiopia (Golubstov *et al*, 2004).

Concerning endemic fish species that are found in Rift Valley lakes, so far, they are represented by a few species, such as, *Garra mekaiensis* from Lake Ziway and Awash basin, *Varicrhinus beso* from the Awash basin, *Denakilia franchettii* and *Lebias stiassnyae* from Lake Afdere, *Nemacheilus abyssinicus* and *Garra ignesti* in Rift Valley lakes (Abebe Getahun and Stiassny, 1998; Golubtsov and Mina, 2002). The same authors also believed that the number of endemic species in the Ethiopian Rift Valley lakes may increase when the taxonomic status of some Barbus and Garra species is studied like what has been done in lake Tana, a high land lake with endemic "species flock" of Labeobarbus.

Globally, scientists estimate that more than 20 % of the worlds 10,000 recorded fresh water fish species have become extinct, threatened, or endangered in recent decades (Moyle and Leidy, 1992). However, quite a number of factors are threatening the fish resources of the country; as yet there is no reported evidence of fish species extinctions in Ethiopian fresh water systems.

Table1. The Fish diversity of Ethiopian Rift Valley lakes (Golubtsov and Mina, 2003)

Family	Number	
	genera	species
Mormyridae-*elephant fish*	3	3
Characidae-*tiger fish*	1	1
Cyprinidae-*carps*	5	13-16
Bagridae-*bagrid catfish*	1	1
Schibeidae-*schilbeid catfish*	1	1
Clariidae-*airbreathing catfish*	1	2
Mochokidae-*squeaker*	1	1
Cyprinodontidae-*toothcarps, killifishes*	2	3
Centropomidae-*Nile perch*	1	1
Cichlidae-*cichlids*	2	2
Total	18	28-31

3. THREATS TO THE FISH DIVERSITY

Many factors have been threatening the fish diversity of Ethiopian Rift Valley lakes. Most of the threats are of anthropogenic origin. To mention the main one's: deforestation, poor soil and water conservation, pollution by both organic and inorganic pollutants from different sources, introduction of alien species and the last but not the least is over fishing. Many of these threats are directly or indirectly related to the water quality as well as quantity of the aquatic environment and they are interlinked to each other.

3.1. Deforestation

Forest destruction is a common problem for all developing countries where food production is the first priority. For instance, South and West African and most of Asian countries have destroyed Mangrove forest along their coastline for shrimp and other aquaculture development. Currently, deforestation is one of the critical problems of Ethiopia as it led to desertification and subsequently the country was subjected to drought and famine several times in its history. Goldammer (1990) reported that forest destruction in Ethiopia is known to be one of the highest, probably comparable to the currently identified "hot spots" of forest destruction in

Tropical Africa and Asia. The present level of deforestation in Ethiopia is about 150,000 to 200,000 hectares of forest per year (Zinabu G/Mariam, 2002).

The main reason for all this destruction are the high population growth and the subsequent high demand for arable land to produce food crops by each household and the usage of wood for fuel and construction. Clearing of forest is exacerbated by poor regeneration due to over grazing by extensively farmed high density livestock population (the first in Africa) such as cattle, sheep, goat and camel. Clearing of forest, animal grazing and other reductions in the vegetation cover of the catchment areas of the lakes leads to high soil erosion by runoff especially during the heavy rainy season (from late June to mid September). The negative impact of deforestation on aquatic systems in general are manifolds and result in major perturbations of nutrient availability, water temperature, turbidity, pH, and water level of associated water bodies (Abebe Getahun and Stiassiny, 1998). Therefore, the fish fauna and other organisms are the final victim of the change in the water quality and quantity of the whole process of the system.

3.2. Poor soil and water conservation

As it is pointed out above there is high destruction of forest and reduction in the vegetation cover of the catchments area of Ethiopian lakes. Furthermore, the improper farming methods and organically poor soils encourage soil erosion. As a result of all these impact, about 1.5 billion tons of soil is lost every year from the highlands of Ethiopia where 70 percent of the population are settled and much of the food crops are produced (Sileshi, 1994). And hence, poor soil and water conservation practice aggravate the problem of aquatic systems as a result of linked processes of soil erosion and sedimentation. Sediment accumulation as a result of erosion covers benthic organisms, depresses oxygen level and reduces light penetration and photosynthesis and thereby reduces the overall available feed for the fish fauna.

3.3. Pollution

Pollution is one of the global problems in the aquatic environment and contributed about 26% of species extinction (Harrison and Stiassny, 1999). The most known large scale activities producing dangerous refuses in the country include garages, car washing centers, petrol stations, tanneries, slaughterhouses, market centers, breweries, hospitals, oil and flour mills, metal works, and many factories, such as, chemical, paint, textile, tire, thread and garment, tobacco, pharmaceutical and cement factories. Moreover, agricultural activities and the domestic wastes and sewages are also the major source of aquatic pollution. All these major sources of pollutants (both organic and inorganic chemicals) affecting the Ethiopian Rift Valley lake ecosystems grouped in three major areas for simplicity in discussion: agriculture, urbanization and industrialization.

3.3.1. Agriculture

Agriculture is the main stay of 83.9% of the population and the backbone of the country economy (CSA, 2008). Therefore, agricultural development is the first priority and agriculture lead industrialization is the economic policy of the country. There are large state and private farms, and small but many fragmented farms in the catchment areas of Rift Valley lakes. On the other hand, agriculture development encourages tree and bush clearing, irrigation, use of fertilizer, pesticides and herbicides, and construction of dams and irrigation canals.

The chemicals and nutrients, especially nitrogen and phosphorous, are carried out from the farm lands of the catchment areas by runoff and join the rivers and then end up in the lakes. The chemicals (e.g. pesticides and herbicides) can be toxic to fish eggs, fish larvae and even to the large ones and to other aquatic plants and animals. The consequences of high nutrient load that comes from the farm lands through run off is obviously eutrophication, which increase the turbidity of the lakes and thereby reduces the light penetration of the water column. That means it reduces photosynthesis and then the availability of oxygen for animals become very low.

Another reason for depletion of oxygen is that, especially during the night, both plants and animals undergo respiration and hence there is high competition for the scarce resource (oxygen) between the mass of plants (both phytoplankton and macrophytes) and fish and other aquatic animals that reside within the ecosystem. Moreover, there is high oxygen demand for decomposition when that mass of plants and other organisms are dying and so creates anoxic condition. Another important phenomenon of Eutrophication (high nutrient load of the aquatic environment) is production of toxic algal blooms. The final consequence of eutrophication which is accompanied by oxygen depletion and toxic algal blooms is mass fish kill. This phenomenon has already happened in the Ethiopian Rift Valley lakes. For instance, Amha Belay and Wood (1982) and Kassahun Wodajo (1982) reported that fish kills, algal blooms and the associated death of wild life happened in Lake Chamo and Abijata, respectively.

Irrigation is one of the most important agricultural activities that are being undertaken by large (state and private farms) and small scale farms. Recently, a number of large scale horticulture and floriculture greenhouse complex emerged in the upstream of Central Rift Valley. The introduction of greenhouses will add to the pressure on local water resources as these greenhouses depend entirely on year-round irrigation while other inputs (fertilizers and biocides) may increase the risk of water pollution. In floriculture, the use of fertilizer nutrients is extremely high due to the high crop demand and the year-round production of cut-flowers (Hengsdijk and Jansen, 2006). The same authors also pointed out that insects are a greater threat for rose than vegetables, while insecticides are most toxic for humans and aquatic organisms but in open field vegetables production less toxic herbicides and fungicides are more frequently used.

Actually, irrigation that is direct withdrawal of water from the lake to the farm lands has no pollution effect for the lake but the direct impact is mainly reducing the water level of the lakes. This situation exacerbated by climate change impacts could be a major threat to the very existence of the lakes. On top of this threat there has also been a great increase in the diversion of several rivers which are the main source of water budget for lakes. The high evaporation rate due to high temperature of the area also magnified the effect of irrigation on the water level of the lakes (Zinabu G/Mariam and Elias Dadibo,

1989). The victim of the decline in water levels is definitely the existing fish fauna as it damages the breeding ground of fish species that spawn in the shallower part of the lake. Withdrawal of water from Lake Ziway and Abijata and diversion of the rivers that inflow to the two lakes and lake Chamo for irrigation purpose has been practiced for the past few years (Zinabu G/Mariam, 2002). As a result the water level of these lakes are declining and the water level of Lake Abijata has dropped about 5m since the late 1960s and its shore has retreated 5 to 6km, thus reducing the lake's size to about half of its original size[3].

3.3.2. Urbanization

Urbanization in close proximity to the Ethiopian lakes is among the greatest potential causes of changes in the water quality and quantity. Most of the fast growing cites like Ziway, Awassa and Arba Minch are in the neighborhood of the

[3]Ecosystem for water, food and economic development in the Ethiopian Central Rift Valley; www.edepot.wur.nl/10668; retrieved January 26, 2011

Rift Valley lakes and the Bishoftu crater lakes are in the vicinity of the flourishing city of Debre Zeit. There are also many mushrooming towns along the shores of the lakes and rivers. All these towns and cities throw their domestic wastes into the lakes. From the urban area, pathogens, heavy metals, huge amount of nutrients, hydrocarbons (like benzene, diesel), oils, washing powders and detergents and so many unknown chemicals with unknown content have discharged to the neighborhood water system. This sewage affects the fish diversity in many ways. To mention some of them:

- They are potential causes of eutrophication.
- Some chemicals, fibers, and plastics can interfere mechanically with gill and respiration may be hardly possible.
- Some chemicals can be toxic to fish.

Lakes that receive water via rivers are relatively less polluted than those lakes that receive directly the sewage from the urban areas as rivers have water purifying capacity along its length. But still some species of fish are in problem as they migrate upstream to the polluted rivers to spawn. A good example is *Barbus ethiopicus,* one of the endemic species of lake Ziway, Ethiopia. This species is endangered because its eggs develop in polluted river waters and the parent stock is exposed to fishery in the lake (Abebe Getahun and Stiassny, 1998).

3.3.3. Industrialization

Industrial development is usually closely associated with the urban growth and leads to the discharge of a wide variety of organic and inorganic chemicals (pollutants) into the water system. Getenet G/Tsadik (2003) reported that in Ethiopia, about sixteen factories have been directly involved into the aquatic systems. The same author also stated that nine factories use surface water, seven factories use ground water to satisfy their water needs and 50% of the factories have been releasing untreated effluents to the aquatic environment (Table 2). In addition to discharging of effluents, mineral extraction (Soda) from Lake Abijata severely affects the water level and the chemical composition of the lake and thereby the composition of the biota including the fish population and the heritage of wildlife it supports has been affected (Tudorancea *et al*, 1999).

Table 2: Industries using and discharged effluents of unknown content to water bodies (EARO, 2002 as cited by Getenet G/Tsadik, 2003)

Types of discharge	Number of factories	%
Treated effluents	6	37.5
Untreated effluents	8	50.0
Discharge not released to water bodies	2	12.5
Total	**16**	**100**

The level of heavy metals and trace elements pollution in some Ethiopian Rift Valley lakes and their in-flows were studied by Zinabu G/Mariam *et al.* (2003). The concentration of heavy metals and trace elements such as arsenic (As = 10 – 700μgl^{-1}), mercury (Hg = 2 – 165μgl^{-1}), chromium (Cr = 104 – 121μgl^{-1}), selenium (Se = 10 – 28μgl^{-1}), cadmium (Cd =5 – 9μgl^{-1}), lead (Pb = 12 – 20μgl^{-1}), iron (Fe = 567 – 4969μgl^{-1}) and molybdenum (Mo = 544 – 2590μgl^{-1}) in some of these water bodies are found to be higher than the maximum permissible level (Zinabu G/Mariam *et al.*, 2003). The same authors also reported that Lakes Koka and Awassa are the most likely impacted lakes by the effluents from nearby tannery and textile factories. High concentration of Hg in a piscivorous tigerfish *Hydrocynus forskahlii* was found from Lake Turkana (Cambell *et al.*, 2003).

3.4. Introduction of alien species

Transfer of fish species between lakes as well as introduction of exotic fishes have been practiced for decades all over the world. The purpose of introduction is manifolds like effective use of ecosystems, improvement of local stock, sport fishing, control of disease vectors and aquatic weeds. However, introduction of non-native species become unpopular as it was shown that it is simply creating unwanted competitors for indigenous species, parasite and disease transmition, predation, hybridization, habitat alteration and many other dynamic changes of system function (Courtenary and Robins, 1975; Fryer and Talling, 1986; Golubtsov *et al*, 2002).

A typical example for the potential negative impact of alien species introduction on native communities is that what was happened in Lake Victoria, the largest Tropical Lake in the world, following the introduction of Nile perch *Latus niloticus* in the 1950s. It was resulted a 10,000 fold decrease in the abundance of native cichlids (Oguto-ohwayo, 1990; Witte *et al*, 1992; Riedmiller, 1994 as cited by Abebe Getahun and Stiassny, 1998). Some scientists also termed that phenomenon the greatest vertebrate mass extinction in recorded history.

Introduction and transfer of fish to natural and artificial water bodies in Ethiopia was first made by Italian experts in the late 1930s and beginning of 1940s and after wards by local scientists (Tudorancea *et al*, 1999). Most of the introductions were undertaken to the water bodies located in the central and south east Ethiopia and Rift Valley is the region with the highest number of introduced species (Shibru Tedela and Fisha H/Meskel, 1981). So far ten exotic fish species has been introduced and these are *Tilapia zillii, Tilapia rendalii, Salmo trutta, Salmo ghiardneri, Ctenopharyngodon idella, Cyperninus carpio, Caracius caracius, Caracius auratus, Gambusia holbruki and Exos species* (Shibru Tedela and Fisha H/Meskel, 1981; Abebe Getahun and Stiassny, 1998).

Besides the exotic species, the native species *O. niloticus* is the commonly transferred species in Ethiopia. On top of these, there was accidental introduction of native species *Clarias gariepinus* into Lake Ziway from Ziway Fish Processing and Marketing Enterprise (Abera Degebassa, personal communication). Most fishermen around Lake Ziway complain about the introduction of catfish (*Clarias gariepinus*) as the catch size of *O. niloticus*, economically most valuable fish, is getting smaller and smaller and the catch per unit effort (CPUE) is decreasing. However, the ecological impact of fish introduction that took place in Ethiopia in the past has not been studied at all. Nevertheless, taking into consideration what has been happening in Lake Victoria and many other inland water bodies all over the world is a real warning signal to others and one must be taken into account.

3.5. Over Fishing

Over exploitation is another major threat caused by human influence to the diversity of aquatic organisms' worldwide. Nowadays, fresh water ecosystems in general are facing problems as a result of over-exploitation (Bugenyi and Balirwa, 1998).

In Ethiopia, the high population growth and the recurrent drought pressurize the people to look an alternative food source. As a result the government gives emphasis to the fishery sector and encourages exploitation of the aquatic resources without fisheries management (and conservation) policy until very recently. As a result in some areas where fishery is active, mainly in Rift Valley Lake Ziway, Abaya and Chamo, the fish catch composition as well as the size of the fish being caught are already changed. These changes are due to alteration in fishing effort and indiscriminate use of particular gear (e.g. gill net with small mesh size and seine nets). For instance, an individual Nile perch caught in Lake Abaya and Chamo used to weigh about 150 kg sometime in the past but nowadays not more than 2 to 3kg. Furthermore, few years ago, the composition of catch in Lake Ziway was dominated by *O. niloticus* and Barbus species but now dominated by introduced catfish and carp species. This is most probably due to the combined effect of species introduction and overfishing of the most economically valuable fish species and may be due to other anthropogenic factors mentioned above.

4. CONCLUSION AND RECOMMENDATIONS

Ethiopia is endowed with different natural and manmade water bodies that encompass about 183 fish species. The floor of the Ethiopian Rift Valley is occupied by a chain of lakes which contain about 30 fish species and are the region where active fishery is being undertaken. On the other hand, a lot of development activities such as agriculture, urbanization and industrialization have taken place and very often these causes pollution of the water bodies via runoff and decline the water levels of lakes. These, together with other anthropogenic activities like over fishing, deforestation and introduction of alien species are the major threats for the fish diversity of the Ethiopian Rift Valley lakes.

However, the ecological impact of introduced fish species, the effluent discharge of many industries and the recently emerged floriculture which are directly involved to the neighborhood water bodies have not been studied yet and nobody really knows what is going on. Until now, there is no recorded evidence of fish species extinction in Ethiopian water bodies. But, change in catch size and composition which is currently dominated by introduced species and decrease in catch per unit effort are already observed. Sedimentation, eutrophication and the subsequent mass fish kills were happened in the Ethiopian Rift Valley lakes. To conclude, the Ethiopian Rift Valley lakes fish diversity are threatened by various anthropogenic activities and corrective measures should be taken before it gets worse and become out of control.

Therefore, the following intervention measures should be taken in the short and long term for the wellbeing of the fish diversity in general and the lake ecosystem in particular.

- The ecological impact of introduced species should be studied and lessons must be learnt for future intervention. Continuous limnological research is also necessary to get baseline data to monitor any change in the physicochemical as well as biological parameters of the lakes.
- Environmental Impact Assessment (EIA) should be done before any development plan is implemented.
- The catch level, the effort to be used and the minimum mesh size should be determined based on stock assessment information.
- The breeding grounds and nursery areas should be protected and the peak breeding season of the year should also be closed.
- The effluent discharge of industries, floriculture and the sewage from urban areas should be treated before it flows to natural water bodies. Constructed wetlands could be considered as one simple, relatively cheap ,but reliable alternative for this purpose.
- Creating buffer/riparian zone; afforestation and promoting agro-forestry particularly fruit trees, changing the farming practices (conservational tillage, contour plowing, strip farming, etc), terracing and other soil conservation techniques should be undertaken in the catchment area.
- Developing and promoting ecotourism.
- The last but not the least is the fishery legislation. The legislation that is developed very recently should be supported by directives and guidelines for its implementation.

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