Past, Current and Potential Production of Fish in lake Ziway

Central Rift Valley in Ethiopia

Capacity Development and Institutional Change Programme
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This document is written on the basis of a number of discussions and field visits. As such this document reflects the knowledge, experience and perspective of many stakeholders interested in the natural resources, ecosystem services and development of lake Ziway.

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1. BACKGROUND TO THE STUDY

The Ethiopian / Netherlands project: *Ecosystems for Water, Food and Economic Development* aims to strengthen local authorities, development organisations and the private sector in the field of sustainable land and water use and sound environmental planning and management, with the aim to contribute to the sustainable development of the CRV .
So far the project has a strong focus on water/ agriculture and over the past few years, the project has developed a sound knowledge base of the problems at stake in the Central Rift Valley (CRV). Major conclusion of the project is that the current way of water and land resources development is not sustainable and will sooner of later result in an environmental and humanitarian crises.
One of the main reasons for this deteriorating situation is the surface water extraction for irrigation purposes by smallholders in the upstream areas, resulting in the watershed-wide drop of surface water tables and increased Stalinization of water resources. These changes directly impact the resource productivity of downstream water resources like Lake Ziway and the Bulbula river. Ultimately the drop in surface water will influence livelihood strategies of communities living down streams and reduce the resilience of ecosystems and the biodiversity of lake Abiyata and the national park. There is ample evidence from similar cases in Ethiopia, that the water resources will gradually become saline, will silt up as a result of increased erosion and will become ecologically poor waste lands.

The government of Ethiopia is fully aware of the impact of upstream water extraction and the need for an integrated approach to resource management in river basins. To this end the Ethiopian Parliament recently endorsed the 'River Basin Councils and Authorities Proclamation'. Although the Proclamation gives River Basin Organizations (RBOs) a legal status and associated mandate, the consequences of this new legislation, in terms of institutional setting, stakeholder consultation, decision making, indicator monitoring etc. are yet unclear. Beside an overall lack of know how, knowledge and expertise to initiate RBO's, a proper institutional setting still has to be deliberated and approved.

Natural resources require particular water levels and seasonal timing of flows to guarantee their optimal use. Changes in water flows in river basins have serious impacts on landscape and biodiversity patterns, water regimes and the connectivity of the ecosystem. Altered flow regimes impact migration patterns, the reproduction, growth rate and production of fish. Wetlands may become dry-lands and loose their function as biodiversity resort. Degradation of formerly productive nursing habitats of fish will seriously reduce production and on the longer term alter the composition of the aquatic life.

There are various synergies and trade offs between agriculture and the production of fish. This study aims to highlight the social and economic value of the production of fish, thus underlining the need to make trade offs in the use of water in a river basin. Just an example of such a trade off: with the reduced (wild) fish production in rivers and lakes, the increasing demand for fish and rising prices for fish in the market, the farming of fish becomes an attractive economic activity. Fish farming needs the agribusiness sector for its marketing chain and the production of fish feed. For both fisheries and the farming of fish clean, flowing water is needed. But the volume of water needed for irrigated agriculture, may limit or even hamper sustainable fish production. Water used for agriculture may in part be returned to the water system, but upstream water intake nevertheless disrupts natural downstream flow patterns and often contains fertilizers and pesticides which may cause fish kill. In other words: a decision on the use of water by one party/ sector may have serious repercussions for the productivity of another party/sector.

Over the years a lot of research has been done and a lot of information collected on the ecology, the fish production and social and economic aspects of lake Ziway. This study is meant to verify and analyze this information in order to appraise the ecosystem services provided by the lake, to discuss the concept of the maximum sustainable yield (MSY) in view of the fluctuating production potential as well as the social and economic importance of the fisheries sector for the livelihood of its stakeholders. The study has made use of existing documentation present at the ministry, research centres and fisheries cooperatives, but also included interviews with public and private stakeholders in the fisheries sector to verify and adjust the information collected.

The report will provide indicative information on current and potential economic value of water for fish production and the impact of changes in water quantity ad quality on the fish production as well as a preliminary identification of opportunities to modulate the current fishing activities to sustainable production levels and market demand.

2. RETHINKING PARADIGMS IN WATER MANAGEMENT

The livelihoods of people living in, or along the borders of lakes and rivers depend partially or entirely on ecosystem services. Loss or degradation of the water balance harms them directly and indirectly as ecosystems play a critical role in their daily life and in maintaining the quality of the environment by absorbing and processing waste products. Strategies to increase food production often entail the withdrawal of water from lakes and rivers for irrigation. And although agricultural food production in the upstream areas may increase, more downstream groups—and society in general—may be worse off as the availability of good quality water gets less. Increasing the irrigated area upstream means less fallow land for grazing in the dry season; water quality may degrade by the use of agrochemicals; reduced water flow may increase human exposure to disease vectors etc.

In the frame of integrated landscape planning, valuation of the natural resources has become an instrument in the development dialogue with the main aim to balance use and management of resources. A valuation of resources was not considered necessary in the past when resources were abundant. But as forests, water resources and natural habitats shrink, environmental services previously provided for free, have become increasingly threatened. Willingness to pay for ecosystem services -though not self evident-, will grow when resources become scarce, hampering people in their development.

In other words the emerging scarcity of natural resources makes them potentially tradable. Therefore it is important to identify and understand ecosystem services, their economic value and to resolve competitive claims on natural resources. However, with respect to ecosystems like wetlands, the assessment of the water flow needed for their survival still remains to be a highly disputed issue. There is no specific baseline state against which to measure the condition of a particular scale ranging from 'natural' to 'extensively modified'. The assessment of the environmental flow needed to maintain these ecosystems has to be based on expert knowledge, comparison with similar least disturbed areas in the region, and the historical knowledge of ecosystem users and local communities.

To make optimal use of natural resources for sustainable rural development, water management policies will have to embrace a broader ecosystem services perspective and pay attention to the need for healthy water by the people, by the ecosystem and by all other economic sectors including the fisheries and tourist sector. Synergies and trade offs with respect to water will have to be taken into account and effective policies and approaches are needed that explicitly recognize the need to address difficult trade-offs between agriculture and ecosystems. Conflicting interests of landowners and other resource users will have to be addressed and solved by means of dialogue and compensations.

Implementation of such policies is however extremely difficult and transaction costs high, especially when many smallholders and multiple actors are involved, when institutions and property rights are weak, and when costs of getting baseline information and monitoring land use and service provision are high. On the other hand economies of scale seem to reduce average transaction costs in larger-scale schemes, such as public, nation-wide payment schemes. In such case, the state will have to provide the system with legitimacy, a system that many private schemes struggle to attain.

Land and water use master plans usually have a strong focus on agricultural production and the development of agribusiness. Water use efficiency is often calculated in terms of (agricultural) production per unit water, thus providing a base for the pricing of water. However the value of water is determined by many other factors and aspects like the need for E (environmental) -flow to secure the functions and services of ecosystems and will be different for the different water users. It is for this reason that the value and *added value* of water needs to be assessed in a multi-stakeholder dialogue to find 'synergies' in water use and ways to mitigate negative trade offs between various economic sectors.

What is actually needed is to develop ways of reconciling the needs for water in a river basin for the maintenance of ecosystem services and the perceptions of the value of water services for economic development by different stakeholders. But calculating the value of water services purely in economic terms is extremely difficult. River basins, like all ecosystems, change over time. Dams, irrigation schemes, reservoirs etc. all contributed to the changes in water flows meant for economic development, while access to water was considered a free right. Economic developments and the social economic environment will have to be taken into account: any increase in production for small holders will have to compete with cheaper food produced by large commercial firms with economies of scale and well established marketing networks. In other words the value of water services is strongly impacted by economic factors and changes in the social economic environment.

3. FROM THEORY TO PRACTICE

Major constraint to develop improved water management policies is the lack of data and information on water for food and ecosystems and the lack of institutional capacity for effective governance as well as institutional arrangements to manage use and re-use of water for sustainable rural development. Basic assessments of site-specific threats, service-provision levels, and opportunity costs of alternative resource use, may help to target policies and practices strategically in space. It goes without saying that effective watershed protection can only take place when people living in that watershed are aware of the ecological and economic consequences of unsustainable resource use and when benefits for adopting (ecologically sound) land and water use practices are obvious and observable in a relatively short time span. Inter-sector dialogues and participatory processes are needed for determining proper land and water allocation, use and management and for the shaping of policies that achieve clearly defined poverty reduction outcomes through fair realistic and transparent decisions. In the policy development process the following aspects need to be addressed:

- Water allocation decisions require valuation methods that reflect the contribution of ecosystems functions to the production and services provided by the ecosystems in terms of nutrition, livelihood security and the development of the rural economy.
- Water productivity calculations will have to take account of the opportunities for synergy and negative trade offs between primary production through ecosystems functions like fisheries and agricultural production.
- Environmental flow requirements need to be understood to secure ecosystem based production and conservation (forests, fisheries and wetland functions & services).
- Information will have to be collected, analysed and incorporated into the basin wide appraisal of land and water resources.
- Partnerships between groups interested in ecosystem based production and conservation (fisheries and other forms of water production) may offer innovative ways for water use and management.
- Accountable governance and management schemes will have to be established taking fully account of the economic and social benefits of inland fisheries and fish farming.

With the recent proclamation of the Ethiopian government to establish River Basin Organisations (RBO), a new era for water management in the Central Rift Valley has started. To foster the establishment and effective functioning of such a RBO including the implementation of the water master plan, capacity building is needed not only to strengthen the overall institutional capacity with respect to natural resource use and management, but also to improve the appraisal of the current and potential land use patterns, the comprehensive assessment of the contribution of water to rural development and ultimately the approximation of the real value of water. Furthermore capacity building is needed to enhance the ability of decision makers to initiate a policy dialogue on natural resource management the Central Rift Valley, to evaluate possible synergies and trade offs between alternative water management regimes and to take appropriate and timely steps to reconcile the demands for water by the various sectors and systems.

Recently a number of studies have been carried out on the impact of the increased use and exploitation of natural resources in the Central rift Valley in Ethiopia. The results of these studies have drawn the attention of the NGO's, the public and decision makers in Ethiopia, to the problems resulting from water scarcity and competing claims on natural resources in the region. The studies focused on the water- agriculture interface, water use efficiency in irrigation, water quality, Stalinization of farmland, improved chain management etc. and included brief outlines of recommended actions , mitigation measures and guidelines for the development of a sustainable resource use and management plan.

The scarcity of water as well as access to water proves to be a prominent factor for rural development in the Rift valley. As yet however, there is very little in place to plan, monitor and counterbalance the use of water in the basin or to apply pre-cautionary principles to the use of resources. In the absence of proper institutional capacity for integrated resources management, rural development in the rift valley, still takes place 'at random', often at the expense of natural resources, the very basis of the livelihood and rural development in the area. The value of land and water resources however, not only relates to agricultural production but is determined by the livelihood of many communities and their -often resource based- economic activities. Especially in case of water scarcity, it is therefore of pivotal importance to assess the value and *added value* of water in a more comprehensive way to find 'synergies' in water use and ways to mitigate negative trade offs between various economic sectors.

The lakes of the Rift valley and its rivers form an important ecosystem and source of livelihood for many, providing benefits in areas of agriculture, fisheries, industrial development, but also in terms of drinking water, livelihood and maintenance of riverside and wetland biodiversity. As such, fresh water sources have influenced if not determined the development of the region and continue to be the defining natural features for the region.

In this context there is a need for appraisal of the impact of the upstream and upland rural development on the Ziway-Abiyata basin as a productive ecosystem and to provide information on the socio- economics of fisheries in lake Ziway. This paper aims to contribute to the knowledge base of the Rift valley and to be an incentive for further studies to arrive at a more comprehensive appraisal of water economy in the Central Rift Valley.

4. ECOLOGICAL ASPECTS OF LAKE ZIWAY

4.1 Geography

Lake Ziway, its tributaries Meki and Ketar and its spill river, the Bulbula, form unique and vital fresh water resources in the central Rift Valley Lakes system in the Southern part of Ethiopia. Together with the lakes Abiyata, Langano and Shala, a high altitude drainage basin is formed referred to as the Ziway-Shala basin. Studies have confirmed that in the past the four lakes (Ziway, Abiyata, Shala and Langano) were joined in one large fresh-water lake that overflowed to the Awash basin to the north. As a result of climate changes, the large lake started to shrink ultimately forming the current four lakes.

Despite their joint history and geographic proximity, the lakes have a different chemistry, morphometry, hydrology and different development prospects. The water level and chemistry of the four lakes are largely determined by rainfall and experience significant inter-annual variability. Because the rift floor is a rainfall deficit zone (evaporation exceeds rainfall), the lakes depend largely on surface water and groundwater inflows from the adjacent plateaus and escarpments.

Lake Ziway is a large open and shallow lake with a catchment of about 6834 km^2, a shoreline length of 137 km and a mean and maximum depths of 2.5m and 9m respectively. Depending the water inflow, the surface of the lake fluctuates between 435 and 485 km$^{2.}$

Five bigger islands are situated in Lake Zeway: Tulu Gudo (4.8 km^2), Tsedecha (2. 1 km^2), Funduro (0 .4 km^2), Debre Sina (0 .3 km^2) and Galila (0. 2 km^2). Currently Tulu Gudo Tsedecha, Funduro and Galila are inhabited.

The major water inflow in the lake is from the Ketar and the Meki River. The Meki River is the largest river, carrying considerable loads of sediments from the highlands to the lake, forming a well developed delta at its mouth in the north of Lake Ziway. The Bulbula river on the other side of the lake, spills excess water from lake Ziway to lake Abiyata. Lake Ziway has a short retention time (about 1.5-2 years) with relatively weak evaporation with respect to inflow, making it a fresh water lake. In effect, it is the only major fresh water lake in the Ziway-Abiyata basin, recommended for its regulatory storage of fresh water and use for irrigation in the basin.

4.2 Water quantity

The water volume of Lake Ziway largely fluctuates according to rainfall in the adjacent highlands. During dry seasons and low rainfall years, the discharge of the feeder rivers is low, reducing the surface of the lake. During long periods without rain, the water level of the lake may become so low that no water will overflow to lake Abiyata. Despite discussions on the impact of climate change on the Rift Valley however, there is no substantial declining trend of rainfall in the region for the last four decades (Ayenew, 2004)

Current irrigation practices in the upstream areas have considerably reduced the volume of the inflowing water from the Meki and Ketar river and other surface and subsurface sources, critically impacting the water level of lake Ziway. According to Makin et al. (1976), expansion of the irrigation area (according to plans) would ultimately result in a 3 m reduction in the level of Ziway, a drastic reduction of lake Abiyata and drying up of the Bulbula River (Tenalem Ayenew, 1998).

Over the past few years the reduced water flow caused a critical water shortage along the spill regime between Ziway and Abyata where the 30 km long Bulbula river represents the only source of fresh water for a large number of rural communities. Maintaining a year round environmental flow strongly benefits the communities living along the river and impacts the ecosystem of lake

Abiyata. When no water is flowing to lake Abiyata, people living downstream of lake Ziway and their livestock have to travel long distances to get water. Local water demand conflicts have grown in the past decade although currently less pressing because of the good rainfall during the past few years.

4.3 Water quality

Aside from problems related to decreasing water level, over-irrigation started to induce Stalinization of farmlands. Excess irrigation and groundwater level rise result in evaporation of water in the top soil and precipitation of salts on the soil surface. The dissolved salts left behind on soil surface not only severely reduce crop growth but also impact the water quality of the lakes when this soil is leached by occasional surface runoff. The impact of the increased Stalinization of the farmland surrounding lake Ziway is still being studied. Simultaneously the application of agrochemicals and fertilizers has increased and impacted the water and soil chemistry of the nearby areas (Hailu *et al*., 1996; Halcrow, 1989; Tessema, 1998; Ayenew, 2004). Recently few cases of the inflow of pesticides were reported.

The quality of the lake water largely depends on the quality and quantity of the inflowing water as the retention time of the water is rather short. With the clearing of the forests in the watershed, silt loads of the feeder rivers and the run off water is increasing, impacting on the limnological system and hydrological conditions of the lake. On the basis of sediment samples taken from Lakes Ziway, Langano and Abiyata, estimations were made of the annual sedimentation rate in the basin using the ^{210}Pb (Lead-210) dating technique (Dagnachew Legesse et al., 2002). Current data suggest a dry sedimentation rate of about 0.75 mm per year, the impact of which is very small when compared to lake level changes induced by reduced water inflow and rainfall. There is however ample evidence from other water bodies that ultimately deforestation and subsequent high sediment transport will lead to siltation of lakes and reservoirs. In some cases the reservoir capacity was lost in only a few years time.
The high sediment loads cause turbidity of water affecting fish breathing and growth, as turbidity hampers light penetration and therefore plankton production and bottom life. Evidence from other lakes in Ethiopia show that the longer term impact of human induced changes like deforestation, increases the risk of flooding such as Awassa Lake or even complete degradation of the lake like in the case of Alamaya. Regular monitoring of the lake limnology is needed in order to understand long term trends in water quality in Lake Ziway and to appraise whether the in- and outflow in this shallow lake (*the environmental flow*) is still sufficiently high to leave the lake with a water quality almost identical to its main inflows, the rivers Meki and Ketar.

Parameter	Unit	Lake Ziway	Lake Abiyata	General trend over the last 50 years
Na^{+}	meq/l	2.4.	249	Stable
K^{+}	“	0.34	7.5	Stable
Ca^{++}	“	0.60	<0.1	Fluctuates
Mg^{++}	“	0.70	< 0.4	Fluctuates
Cl^{-1}	“	0.38	71	Stable
$SO4^{-2}$	“	0.40	19.5	Fluctuates
Total cations	“	4.04	256	Increase then decrease
Total anions	“	4.31	278	Increase then decrease
Conductivity	µS/cm	370-410	22 900-28 300	Fluctuates (Abijata)
Alkalinity	meq/l	3.6	325	Fluctuates (Abijata)
SiO2	mg/l	46	114	Stable
Phosphate (SRP)	µg/l	219-282	3200	Increasing trend
Nitrate	µg/l	3.9	8.1	Increasing trend
pH	-	8.9	10.3	Stable
Salinity	g/l	0.40	18.2 (26.4)	Increasing in Abijata?
Chl A	µg/l	91	60	Decreasing in Lake Ziway?

Chemical composition and changing trends of the water of Lakes Ziway and Abijata (after Schroder, 1984; Wood & Talling, 1988; Zinabu Gebre-Mariam et al., 2002; Elizabeth Kebede et al., 1994; 2002, Seyoum Mengistou, 2004.

5. ENVIRONMENTAL FUNCTIONS AND SERVICES OF LAKE ZIWAY

Environmental flows (E-flows) in many river basins required to sustain productive ecosystems like wetlands and fisheries, are not known and therefore not taken into account in rural development planning. Recent studies on the functions and services of wetlands like lakes and rivers have shown that the true economic value of 'wetland production' can be remarkably high. These studies considerably altered the thinking about E-flow and perceptions on water use efficiency.

Lake Ziway still holds the intrinsic value and aesthetic quality of a wetland, including its functions like shelter for a rich diversity of plants, aquatic birds and fish and ecological functions like filtering pollutants and sediments, buffering against wind and storm etc. The marshes around the lake support several waders, both of intra- African and Northern species while roosts of several thousands of cormorants, ducks and geese can be observed around the lake. The long shoreline of lake Ziway is covered with submerged vegetation and especially in the south, papyrus and emergent grasses, reeds and *Scymora* trees. In the less inundated areas the lake offers suitable farm and grazing land when the water level is low and breeding and nursery places for fish when the level is high. When properly managed and monitored, lake Ziway has a good potential for the development of tourism with a focus on wetland aesthetics with its riparian forests, hippo's and birds and making boat trips to the islands with hot water springs, local traditions and fish barbecue attractive activities.

Lake Ziway is stated to be an oligotrophic lake with limited fish production capacity. Low N:P ratio for Lake Ziway (< 8) indicates that Nitrogen rather than Phosphorous is the limiting nutrient for algal growth although the activities of nitrogen fixing blue-green algae may at least partly compensate for this. Studies have shown that so far there are no significant changes in water quality, except for a slow concentration change in salinity and mineral content for the last 35 years, which may be attributed to increased run off.

With the increasing impact of human activities, however, the wetlands bordering the lake appear to become more eutrophic, which may explain the comparatively high productivity of phytoplankton in the littoral zone (Getachew Beneberu, 2005). The absence of large zooplankton in Lake Ziway implies that the main grazers are Rotifers feeding on smaller phytoplankton species. The larger algae such as *Microcystis* are largely un-grazed by both zooplankton and fish. Blooms of these blue green algae are an indication of nutrient rich waters and may have a negative impact on the functioning of the lake ecosystem as blooms cause strong fluctuations in dissolved oxygen and fish kills. Moreover eutrofication may induce the development of floating mats of vegetation and extensive growth of rooted aquatic macrophytes which may interfere with navigation and hamper fishers to land their catch. Over fishing of especially the shores of the lake has the potential for severe and unexpected impacts on the health of humans. For example the trematode parasite responsible for schistosomiasis is vectored by snails of several genera that are consumed by cichlid fish like the Tilapia. Increases in vector snail populations released from predatory control by cichlids fishing are a likely consequence of over fishing.

Lake Ziway experiences direct but also indirect environmental stresses. The fluctuations in rainfall, water withdrawal for irrigation, deforestation and farming activities in the upstream area, all have their own effect on the ecology of lake Ziway and therefore the economy of its fishery. The ecology of the lake also changed because of the introduction of catfish and carp, fish species which were not present in the lake before.

High rainfall enriches the lake with fertile nutrients entering as runoff through its tributary rivers. It also enlarges the size of the lake, which induces flooding of shores, followed by release of nutrients and growth of plankton to the benefit of the re-production and growth of fish. Irregular rainfall may however also increase run off water and increase the turbidity of the lake water, hampering photosynthetic activity, primary production and the breathing of fish. Similarly drought and reduced inflow of water, will have a negative impact on the ecology of the lake, the breeding and nursery grounds and its fish stocks. The high catch drop in late 1970s is for instance attributed to the recurrent drought existing in Ethiopia in that period. The reduced production of the last few years may also be attributed to the low rainfall but may very well be aggravated by the reduced inflow of water from the rivers Ketar and Meki.

6. SOCIO-ECONOMIC VALUE OF LAKE ZIWAY

Inland fisheries (and the farming of fish), provide food, income and employment to the rural population. Despite their social and economic role, fisheries and fish farming are greatly undervalued in water resources planning and management. Unlike crop production, fisheries can provide year round production and income. As such ecosystem based production like fisheries provides a form of social security for vulnerable households when the agriculture based rural economy is stressed due to irregular rainfall or factors beyond national control.
One contributing factor to the lack of attention for the fisheries sector may be that the environmental flows in many watersheds required to sustain fisheries are not known and therefore not taken into account in rural development planning. Recent studies on the functions and production of wetlands however, have shown that the true economic value of 'wetland production' can be remarkably high. These studies considerably altered the thinking about E-flows and perceptions on water use efficiency.

Inland fisheries including the farming of fish, provide food, income and employment to the rural population. These benefits are however largely unacknowledged in water resources planning and management. Rural Development Master plans usually have a strong focus on agricultural production and the development of agribusiness and do not include fisheries. But unlike crop production, fisheries can provide year round production and income, at times when other lucrative labour opportunities can not be found. Ecosystem based production like fisheries thus provides a form of social security for vulnerable households when the agriculture based rural economy is stressed due to irregular rainfall or other biotic and a-biotic factors beyond control. Factors contributing to the lack of attention for the fisheries sector may be that the socio-economics of fisheries are obscure for outsiders and that over-fishing is considered a kind of permanent, non restorable situation.
Beside fishing effort, there are a number of other factors impacting the fish production. Like other natural resources, lake Ziway requires a particular water level and seasonal timing of flows to guarantee the survival of its ecosystems and biodiversity. Rainfall forms the major incentive for the reproduction cycle of the fish and other aquatic life. When the rain starts, the lake water is rising and the shallow shores of the lake will become fringed with submerged wetlands and floating vegetation. Near the shores comparatively high concentration of phytoplankton can be found, forming an excellent nursing ground for juvenile fishes.

Changes in water use in the river basin have serious impacts on flow regimes and the connectivity of the ecosystem. For instance changing water flows may impact on the migration patterns and reproduction of fish; strongly reduced water levels may degrade formerly productive nursing habitats of fish and other aquatic life and reduce the resilience of ecosystems in terms of production and conservation of biodiversity. Due to lack of rainfall and increased withdrawal of water for irrigated agriculture from the Meki and Ketar river and lake Ziway over the past few years , the water level of the lake was critically lowered, impacting the fish reproduction as most of the breeding and nursery grounds were lost. Only recently the water level increased after some good rainfall and the nutrition-rich shore lines were flooded again providing food and shelter for the fish. According to expectation the fish production will restore itself, provided there will be no stress in terms of fishing effort or low water levels.

Visit to the Island Tulu Gudo

Fisheries is the main source of food and income for the island which used to pay tax in the old days in the form of dried fish. Being traditional fishermen, they all are fully aware of the vulnerability of the fish stocks and realise that without proper management regulations, fish production in lake Ziway will remain a 'wild card'.

But there are hardly other sources of income. They are forced to continue fishing, even when fishing is no longer cost effective.

The fish harvest had been low for many years, because the water level had been extremely low and the shoreline had moved away for more than 10 meters. The swampy shore areas which are the breeding and nursery grounds for the tilapia dried out, making the reproduction and growth of the fish impossible. Only now that the water level is better, they observe signs that the fish is recovering and the fisher folk hope for a better future. The island seriously suffered from the lack of good fish harvesting. Several islanders started to cut and sell trees as they did not have other economic activities.

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7. FISHERIES PRODUCTION OF LAKE ZIWAY

Ethiopia has a large population which provides an increasing market for fish and fish products. Traditionally the Christian orthodox people observe about 80 days of fasting during certain periods of the year. In addition they fast twice a week all year round. During these periods of fasting, many prefer to consume only fish and no meat, a custom which causes high demand for fish during the fasting periods. Fish consumption is highest around the lakes and along rivers but also in urban areas. Fish is well accepted, considered to be a very rich source of protein and is (still) relatively cheaper than meat. Nowadays fish production wields a good esteem in terms of employment, income generation and food security.

Fisheries on lake Ziway was and still is an open and easy accessible source of income and has always been a source of food and income for the islanders and people living on the shores of the lake. Over the past two decades, the demand for fish has considerably increased, especially in the urban areas. The creation of the state owned Fish Production and Marketing Cooperation (FPMC) in Ziway in the early 90 ties, opened markets which were hardly accessible before. It was only after the establishment of the fish processing and marketing industry, that fisheries became a viable and attractive economic activity. As a consequence however of the strongly increased fishing effort the stocks became overexploited and a total ban on fisheries was installed for 2 years to give the fish a chance to recover and fishermen moved to other lakes like Awassa and Abiyata.

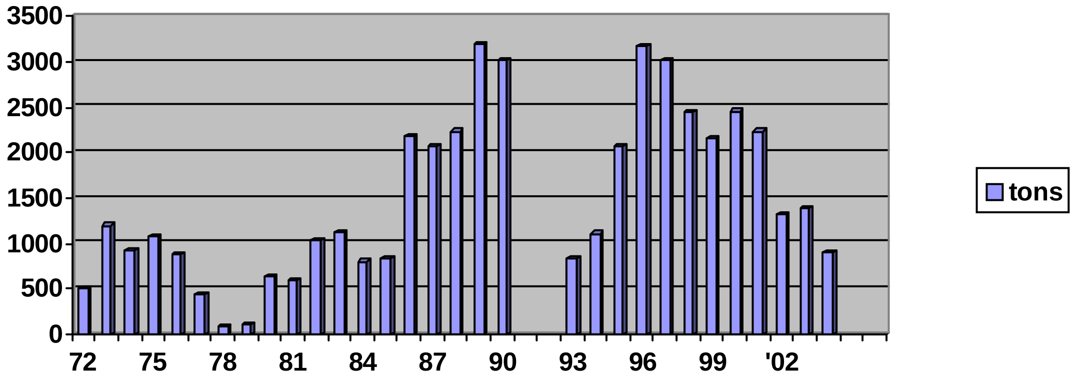
Over time, the role of the private sector has become more prominent. Cooperatives of fishermen became stakeholder owned and ruled institutions and recently the fish processing factory in Ziway was privatised. Presently there are 12 fisheries cooperatives landing their catch at various landing sites for consumption in their communities and marketing through private or other market channels.

The Tilapia are the most dominant and the most preferred species in Ethiopia. In most east African lakes, the Nile Tilapia matures within 10 to 12 months when reaching 350 to 500 grams. The adult fish may grow to a maximum size of over 4 kg and may become 10 years of age. Environmental conditions however have a strong influence on the growth of the fish and the moment of sexual maturity and Tilapia are known for their ability to sexually mature at a much smaller size: around 8-10 cm (3-4 in.) in body length and an age of less than 3 months old. When growth is slow due to lack of food or stress, the sexual maturity of the tilapia is delayed a month or two, but stunted fish may spawn at a weight of less than 20 grams (Chapman, 2000).

In the early 90 ties the size at first breeding of Tilapia in lake Ziway was stated to be between 15 and 18 cm. Over the years this size became less and less due to increased fishing pressure in which the minimum mesh size for gill nets was reduced from 10 to 8 cm. In this way the larger parent fish was caught, thus reducing the number of eggs per female parent fish and the stress on the remaining population was increased. Nevertheless according to expectation the reduction of the size of first breeding was not to have any adverse effect on the spawning result of Tilapia. The Tilapia spawn in a nest excavated by male. The male fertilizes the eggs and then the female fish 'eats' the eggs: she holds and incubates the eggs in her mouth until they loose their yolk sag and start looking for food. The peak breeding season of Tilapia is between December and July. Landings of fish in lake Ziway generally increase during January – March due to the high demand for fish during the fasting period. In other words fishing effort increases during the vulnerable stages in the life cycle of both the parent and the juvenile Tilapia fishes.

A number of catfish, a rather predatory fish species brought alive in the early 90 ties to the Ziway fish processing and marketing factory for being filleted, managed to escape to the nearby lake Ziway, reproduced well and changed the aquatic ecosystem and composition of species in the lake. The Crucian carp was purposely introduced in the lake during that same period. The carp is a bottom feeder and filled in a gap in the food chain and managed to settle well in the lake.

The increased demand for fish and the favourable prospects of the sector induced a considerable influx of fishers and gears. Fishing effort increased in a few years to such an extent that the fish stocks soon reached and even surpassed the level of Maximum Sustainable Yield (MSY). With an estimated annual production potential of 67 kg/ha., the fish production of lake Ziway is high compared to other lakes in Ethiopia. This is mainly due to its favourable ecological conditions, but which may partly also be attributed to the presence of a viable market outlet like Addis Ababa. The landings of lake Ziway used to be dominated by Tilapia nilotica (Oreochromis niloticus), but for the last ten years the African catfish (Clarias gariepinus) and Crucian carp (Caracius caracius) are increasingly becoming part of the catch . Currently the composition of the stock is estimated to be about 70 % Tilapia , 20 % carp and 10% Catfish.
The potential yield of all species of lake Ziway, that is the fisheries 'resource rent' which can be tapped without damaging the parent stocks, has been assessed by empirical modelling and is estimated to range between 2,500 to 6,680 tons/yr. depending the surface of the lake. The maximum sustainable yield (MSY) of Tilapia was estimated to be around 2,100 tons/yr. Data collected over the years show that according to statistics this MSY was never attained and one may conclude that there is still ample room for increasing fish production. Despite the political wish and endeavour to increase production, it was confirmed in the early 90 ties that Lake Ziway was exploited close to its MSY, implying that increasing the fishing effort would end up in over-fishing of the parents stocks.



Virtually, fisheries statistics may not show the real picture of the fish production, because of a number of errors in the collection of the data like:

- Access to the fisheries is open to all (none licensed). The exact number of fishermen is not known. Consequently calculations on the basis of the average catch per fisherman or boat, times the number of fishers/ boats are incorrect;
- Private fishermen may land and sell their catch unregistered;
- Landings are dispersed and according to FAO are underreported by a factor 3 to 4;
- Different institutions may use different data collection systems, so the data are not compatible;
- Home consumption of the fishers is not registered;
- Data may only be collected at certain landing sites;
- Fishermen esp. cooperative members may not provide correct information in order to keep part of the catch for their own benefit.

Furthermore statistics may not depict the actual information on the situation and may be explained and commented as follows:

- The estimation of the maximum sustainable yield is based on modelling only and needs to be scaled down;
- when the catches become lower, fishers may not go out fishing so often as the costs of fishing outweigh the benefits. When however there is no alternative livelihood, fishers may continue fishing and may even start using detrimental fishing practices, further damaging the stocks;
- balancing the fishing effort with the optimal resource rent is needed to keep the fisheries an economically attractive sector. Close monitoring and control is needed on the maximum allowable number of fishermen/ gears ;
- research on catch composition and the length weight relationship show that especially the Tilapia suffers from stunted growth caused by stress, probably due to a combination of low water levels / reduced availability of suitable breeding grounds and too high fishing pressure;
- In 1985/86 a fish ban was ordered to give the stocks the possibility to restore themselves. It was proven that the fish ecosystem is able to restore itself in 1-2 year provided the conditions are favourable (high enough water level and no or limited fishing activities).

Inland fisheries like in lake Ziway are complex in their multi-gear and multi-species aspects, in their inter-annual variability as driven by abiotic factors and in their social and economic context. Systematic over-fishing of inland waters is largely unrecognised because declines in fish production takes place within a complexity of other often external pressures, the consequences of which are poorly understood. According to assessments of the maximum sustainable yield (MSY) in lake Ziway, the current fish production can be considerably increased. The unreliable statistics on fish production however, and the proven responsiveness of especially the Tilapia to environmental fluctuations in the lake makes such statements for the fish production of lake Ziway insignificant.

The ecological reality is far more complex:

- It is not always easy to notice over-fishing as one of the symptoms of intense fishing is the decline of certain stocks even as the overall fish production rises, though over fishing is evidenced by changes in composition and mean length of the fish caught reduced size at first maturity.
- Over-fishing may not immediately cause declines in total catch as fishers may shift their fishing effort (gears, fishing grounds, fishing time). Moreover fish populations frequently respond to heavy fishing pressures with reduction in mean body size and size of first maturation. As over fishing reduces the mean size of individuals, fishers may decide to reduce the mesh size of gear they use. Consistent declines in mesh size is a clear indicator of the state of the fishery as small size mesh size nets are expensive and time consuming to make and usually will be adopted by fishers only out of necessity.
- Intensive fishing frequently acts synergistically with other pressures and ecological events. It's consequences for inland fisheries and the ecosystems are poorly documented and taken into account. For instance the growth and reproduction of fish responds to the rainfall and the flooding of the nutrient rich shores. Consequently catches correlate to rainfall and in times of less rainfall recruitment will be less. A lag in response in the catch, to increasing water level may indicate that the fishery is based mainly on the recruitment of young fish entering the fisheries. During prolonged periods of less rainfall, stocks will be seriously reduced.

Ultimately over- fishing will reach a stage beyond the level of commercial profitability. Parent stocks will be reduced to such an extent that the larval recruitment rather than capture of mature fish becomes the primary reason for low abundances. Fishermen will stop fishing, but may resume fishing as soon as possible, often out of economic necessity, impeding the stocks from proper recovering.

8. FISHERIES MANAGEMENT IN LAKE ZIWAY

Fisheries in lake Ziway is just like in the other lakes and rivers in Ethiopia, based on the principle of open access to resources. Most fishermen are organised in cooperatives, representing the communities around the lake and on the islands. Fisheries is, more or less restricted (at least in word) to the cooperatives , although a considerable number of individual fishermen are operating outside the framework of cooperatives, simply because fishermen do not have to be registered as such nor do they need to have a license to fish.

Despite Federal Proclamations DATE to restrict access to fish resources, implementation of fisheries policies in lake Ziway is still pending and fishermen or cooperatives still do not have to pay for access to resources. Private fishers are often accused of being illegal, unorganised and not being liable for any governmental obligations. On the other hand cooperatives are also not liable for any payments to the government for use of the fish stocks. The cooperatives claim to adhere to common regulatory measures of lake Ziway like mesh size regulation, quota for fish species and closed seasons or areas. Most fishermen however still use illegal fishing gears.

In general fishermen are well aware on the re-production cycle of the fish, the feeding behaviour of fish, the value of the breeding and nursery grounds etc. as well as the need for using only appropriate fishing gear. Private fishers may sell their catch to a cooperative member, but in many cases, private fishers will use the fish for home consumption or sell to local fish traders. The members of the fishers cooperatives generally land their fish at a place close to the processing factory.

The management of the fisheries sector is rather complicated as there are 5 woreda's around the lake each with its own policies, rules and regulations hampering the development of a common fisheries management strategy. The most common traditional regulatory measures of lake Ziway are mesh size regulation, catch limits, and closed seasons or areas. Allowed mesh sizes for beach seines and gill nets are 8 and 10 cm respectively. Fisheries management measures like closed seasons, closed fishing areas, restriction on the number of fishers, catch quotas, mesh size restriction, restriction of beach seines and banning beach seines may all be acceptable options, be it that control should be effective and preferably based on the cooperation with and social control by the fishermen themselves, as the many landing points along the full length of the shoreline makes implementation and control especially of area closures rather difficult and costly.

Until proper management measures will be in place including the introduction of a licensing system and regulation of fishing effort, the economic stability of the sector will remain uncertain. As long as total revenues exceed total costs and profit is there, effort will rise, sooner or later resulting overexploitation and loss of resource rent. Equally it can be expected that when the stocks are getting less, any rise in effort would make business at loss as the cost of effort is greater than the revenue. When however prices offered for fish are increasing, fishing effort might increase again, when a fisher can afford the cost.

In the case of lake Ziway this situation tends to perpetuate due to lack of alternative income generating activities. Studies show that the larger part of the fishing communities along the lake depend on fisheries only. About 46 % of the fishermen owns land, livestock and has other means of living.

Biological concepts of maximum sustainable yield have largely failed to create enough support for sustainable management of fish resources. Fisheries management formerly considering only biological & ecological aspects, have now largely been replaced by new models that incorporate both biological and economic considerations thus reflecting the interaction between markets and production, the costs of fishing, the impact of fishing effort on the stocks as well as considerations of the fishermen with respect to target fishing, willingness to restrict their fishing activities etc. From economic point of view it might be important to consider fisheries management in relation to its bio-economic return, considering yield with respect to the revenue it earns and the expense it incurs.

According to bio-economic fisheries management, the estimation of the resource rent and the calculation of the costs of the effort to harvest this resource rent, determines the economic viability and ecological sustainability of the fisheries sector. Economic data will have to show the proper fishing effort or break-even point, that is when the costs of fishing are more or less compensated by earnings at least for part of the fishers. In bio-economic fisheries management it is not so much the maximum sustainable yield, but rather the interaction between the market and the production that determines the viability of the sector.

The resource rent is estimated by the composition of the stock, the size of the parent stock and by the growth rate of the different fish species of the standing stock. Growth rate however, is not a fixed factor, but may differ depending the nutrient inflow in the lake, the carrying capacity of the ecosystem, the size of the stock etc... The lower the stock biomass, the higher the growth rate of the fish, because of the availability of ample food and space that triggers recruitment and growth of the existing stock. The viability of fishing activities not only depends on the size and health of the stocks, but also on the cost benefit ratio of the fishing activity. In the case of fishermen, the costs of fishing should be balanced against the prices offered for the fish at the landing site or on the market. If the prices at landing site are low, fishermen will (have to) catch more fish in order to get a decent income.

In lake Ziway the number of fishermen and their fishing effort, reduced considerably over the past decade. According to documentation (LFDP, 1996; Getinet, 2002, Ahmed Mohammed et al. 2004) the number of cooperatives decreased from 20 to 12, reducing the number of fishermen by almost half. Simultaneously the number of boats slightly increased as well as the number of beach nets, and hooks and lines. The largest reduction however is in the number of gill nets from 2470 to 70! (= 74%). Simultaneously the considerable reduction in the number of fishermen and the number of gill nets may indicate that the gillnet fishing for Tilapia has not been profitable over the past few years. From these data it may be concluded that about half the number of fishermen are still active, merely using hook and line for fishing catfish. Interviews confirmed that fishermen are trapping young fishes with beach seines near shores, to use the young ones for bait to catch catfish.

Fishing effort	Cooperatives	Fishers	Boats	Beach seines	Gill nets	Hook & lines
LFDP, 1996	20	1760	120	124	2470	1056
2004/05 *	12	904	132	134	70	977

Fishery production system in mid rift-valley of Ethiopia, Ahmed Mohammed et al.

Although statistics are not conclusive, it is stated that presently there are 253 fishermen registered as members of a cooperative, 430 not registered fishermen and 424 crew members. In addition there are over 3000 people involved in ancillary services like boat building, net making, fish filleting, fish transport and trading etc.

9. THE LANDING, PROCESSING AND MARKETING OF FISH

According to fishermen the price for fish differ per species (whole or filleted) and moreover fluctuates depending the fasting and non fasting period. In general filleted fish (33-38 % of the whole fish) catches a better price on the market. Price of catfish depends on the place of selling/ market. Although the market for catfish is improving over the past decade, in general catfish is still not a preferred fish species. Catfish do not have scales and are considered a forbidden fish for religious reasons. Some (esp. elderly) people do not want to eat the fish because they are not used to it or because of its features (personal communication). In other areas eg. around lake Beseka people eat only catfish and special programmes are needed to promote the consumption of Tilapia.

Year	Fasting season			Non fasting season		
	Tilapia	Catfish	Carp	Tilapia	Catfish	Carp
1995	1.25	1.00	0.00			
1996	2.50	1.25	0.75	1.50	0.75	-
1997	2.50	2.00	-	-	1.25	-
1998 [2]				1.50	1.50	-
1998				2.00	1.75	-
1998				4.00	3.00	1.00
1998				3.50	2.50	
1998				2.00	1.50	
1999	3.50	3.00	0.75			
1999	2.50	2.25				

[2] Prices were adjusted several times

2007	Price per kg in Birr					
	At landing site, whole fish		Market, whole fish		Market, filet	
Fish species	Non fasting	fasting	Non fasting	fasting	Non fasting	fasting
tilapia	1.5-4	4-5	8		10-20	
catfish	1.5	3.5			5-9	
Carp	0.5					

This table indicates that fish price on landing site, which is the fishers selling price, is very low as compared to that of traders at the market, whether it is whole or filleted. Actually these prices do not differ much from the prices mentioned in studies carried out in the 80ties, when a price of 2 Birr per kg for a Tilapia at landing site was taken as an average. Meanwhile it can be expected that the costs of fishing especially the costs of fuel for outboard engines have increased as well as the costs of living.

The fish is landed at various landing sites along the lake depending the prices offered. Studies show that about half of the catch is sold to the (formerly) state owned Fish Production and Marketing Entreprise (FPME) with over 50 employees. About 30% of the catch is sold to private traders, less than 5 % is directly sold to hotels, while the remaining 10% is meant for home consumption.
Due to low fish production, the FPME decided to close down for a period of 7 months in the late 80ties. More recently it was recently decided to sell the Ziway branch of the FPME to a private owner, as the fish trade from lake Tana proved to be far more profitable. At the moment of the visit, large amounts of spoilt fish were observed near the processing factory, the lake site and the wetland. Transport of spoiled fish to the nearby feed production plant did take place, be it irregular and not well organised. It was stated that fish production from the lake had been reduced to such an extent that the Fish Processing and Marketing Cooperation had to reduce its activities and as a consequence the processing of the fish offal also stopped.
Fish offal used to be processed by a nearby processing plant for the production of chicken feed. According to information the feed production plant in Ziway is buying fish offal for 10 cents / kg. to produce dried fish meal for a price of 4 Birr/kg. With a conversion rate of 5:1 this gives an added value of 3.5 Birr /kg.

Attempting to earn resource rent from fishery (or rather save resource rent from dissipation), which could be achieved by reducing and controlling the existing effort might be difficult for lake Ziway. In view of the low prices for fish at the landing sites and the profits made in the processing marketing chain, it might firstly be better to make a market analysis and to explore production-market arrangements to make best use of the lake.
To this end, the value of lake Ziway, in terms of fish production, its provision of employment and income will have to be based on an appraisal of the economic situation.
However, in a situation of open access to resources and lack of alternative income earning opportunities, the characteristic 'tragedy of the commons' will continue to prevail, also for lake Ziway. In view of the current situation the best way to manage the resources is to initiate a viable and sustainable fishery sector by adopting a participatory approach to resource management:

Let's assume that a family needs 10 Birr per day for a decent income. With the current prices for fish at landing site this means that each fishermen should make an average daily fish catch of 2.5 kg Tilapia or 5 kg of Catfish. When prices are higher, a fisherman do not have to fish more, but he will be inclined to do so attracted by the perspective to earn more. But when a license to fish is combined with quota and fishermen do understand the argument of imposing quota for the catch, they may be willing to cooperate as they are the owners of the resource.

Simultaneously management of the lake basin will have to accommodate the wide array of economic and social benefits that people derive from fresh water ecosystems, like food security and economic resilience, including the benefits from fisheries. Appropriate institutional structures and legal frameworks are needed allowing stakeholders participation in resource use and management. Such decentralized systems will by definition involve local people to a greater degree in decision making, resulting in more flexible management systems with greater likelihood of formulating and enforcing regulations that corresponds best to the experience and needs of the fishery at the local level. At present such a management system is lacking.

10. STRATEGIC APPROACH TO SUSTAINABLE DEVELOPMENT OF LAKE ZIWAY

A healthy and productive Lake Ziway requires a strategic approach for sustainable development in which an appropriate balance is fostered between ecosystem protection and economic development. Such an ecosystem-based economic development may be in terms of fisheries, fish farming, organic horticulture along the shores, in combination with wetland tourism. But also in terms of institutional governance to ensure efficient and equitable use of water, lakes and wetlands by all stakeholders in the basin. Not only for lake Ziway, but also for the livelihood of many, living in the downstream valley, it remains crucial:

- to maintain the flood regime as much as possible;
- to reduce soil erosion by strictly controlling cattle grazing in wetlands;
- to carefully monitor land and water use;
- to ensure that the catchment / river basin remains as forested as possible.

Human access to and use of the shores and the lake should be in line with the carrying capacity of the lake and riverine forest. This actually implies restricted access, community run monitoring schemes especially to prevent fishing at the river mouth where the fish breed and to restrict certain types of fishing gear , closed seasons, etc .

Beside the implementation of a solid and well accepted fisheries regulating and control system, regular surveillance and monitoring of indicators of the health of the fish stocks, presence of water born diseases etc. and the aquatic ecosystem like turbidity, nutrient content (phosphorus and nitrogen), salinity, vegetation, bird and other animal life are needed, to verify and fine tune conservation strategies, ecosystem protection measures as well as sustainable use of the resources for the well being of the lake communities.

Provision of socio-economic benefits from ecosystem services to a broad spectrum of resource consumers as in the case of the Ziway/ Abiyata basin requires the development and implementation of integrated river basin management plans as well as strategies that consider pressures occurring across multiple scales through a process that include all stakeholders who have an interest in how basin resources are used.. The current and potential impact that the lake and its related fresh water systems experience from upstream and upland activities should be assessed, mitigated, monitored and incorporated in the planning, use and management of resources in the Rift Valley. Methods of promoting systems of multiple use management systems identified and incorporated into national policy achieving the sustainable use of wetlands and of meeting the livelihood needs of a range of beneficiaries.

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