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Fisheries production system scenario in Ethiopia

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Abstract
Ethiopia has 12 river basins with an annual runoff volume of 122 billion m^3 of water and an estimated 2.6 - 6.5 billion m^3 of ground water potential, which makes an average of 1575 m^3 of physically available water per person per year, a relatively large volume. Thus, the country has substantial fishery resources in the inland lakes and rivers. The potential yield of fish is estimated around 51,481 t/year for the main water bodies, of which only around 24% is exploited presently. Hence, for most water bodies, the production exploited is far below the estimated potential yield. There are several reasons attributed to the low production among which the age-old fishing methods, economic backwardness, adverse religious practices, most of the fish catches from the lakes reach the market by traditional means of transportation without any preservation facilities, poor fish marketing traditions, lack and implementation of fishery regulation policy; and infrastructure; and also in some cases aquatic pollution. In addition to these open accesses to the resources have resulted in mismanagement of the fishery resources. Hence, the issue of appropriate management is an urgent need to address for the contribution of the fishery as a source of food, income and employment for the majority of the population around the lakes in particular and in the country in general. This can be done either by the government or by the fishing communities themselves or by both.

Keywords: Capture fishery, constraints, culture fishery, Ethiopia, freshwater

1. Introduction
Providing adequate food for a rapidly increasing human population is one of the greatest challenges in the world. The problem is particularly acute in countries like Ethiopia where, besides population explosion, natural and man-made calamities have aggravated the problem. In addition to increasing food production from land agriculture, it is necessary to sustainably exploit the aquatic ecosystems to contribute towards the effort of food security by virtue of their high productivity. Ethiopia's fish resources could undoubtedly offer one of the solutions to the problem of food shortage in the country. The ecological diversity and climatic variation of the country is to a large extent explained by its highly variable topography, which implies that Ethiopia is a country of enormous habitat diversity. Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems, including river basins, major lakes, many swamps, floodplains and man-made reservoirs Hence, the water bodies support a diverse aquatic life including more than 200 fish species of which about 40 are endemic [35].
Almost all the fish consumed in Ethiopia are collected from the wild using artisanal methods. The current total fish production potential of the country is estimated to be around 51,481 tons annually for the main water bodies, of which only around 38,400 were exploited very recently [19]. According to Brook Lemma [11], although there are some form of fisheries practiced in most freshwater bodies in Ethiopia, commercial fishery is concentrated at Lakes Tana, Chamo, Ziway, Abaya, Koka, Langano, Hawassa and Turkana. The major fish supply to the major cities and towns in Ethiopia are captured from the Rift Valley lakes (40%) and Lake Tana (50.2%) in the north [40] and the remaining percentage going to reverine fisheries. For instance, the rivers and floodplains in Gambela Region are estimated to have annual fish yield potentials of 15,000 to 17,000 tons [27], while the rivers and floodplains in Benishangul Gumuz Region are estimated to have potentials of 2,400 tons per year [4]. However, there are constraints that related to age-old fishing methods, economic backwardness, open access to the resources and poor fish preservation and marketing traditions. Hence, the objectives of this paper are to review the existing status of fisheries production and draw important conclusions and recommendations of the fishery resources of the country.

2. Water Resource Potentials and Fish Fauna

The country has 12 river basins. The total mean annual flow from all the 12 river basins is estimated to be 122 Billion Metric Cube (BMC) [34]. In addition the country has 11 fresh and 9 saline lakes, 12 major swamps and a lot of crater lakes. The majority of the lakes are found in the Rift Valley Basin. Most of the lakes except Ziway, Tana, Langano, Abaya and Chamo have no surface water outlets, i.e., they are endhoric. As compared to surface water resources, Ethiopia has lower ground water potential. However, by many countries' standard the total exploitable groundwater potential is high. Based on the scanty knowledge available on groundwater resources, the potential is estimated to be about 2.86 BMC annually rechargeable resources.

The freshwater fish fauna of Ethiopia is of particular interest since it contains a mixture of Nilo-Sudanic, East African, and endemic forms [1, 35]. A publication on the Ethiopian Ichthyofaunal studies by the Joint Ethio-Russian Expedition (JERBE) since 1984, presents relatively an exhaustive summary of the number of families, genera and species occurring in the country's various drainage basins. Accordingly, the Baro-Akobo drainage basin appears to be the most species rich (113 sp.) in 60 genera and 26 families. Moreover, the basin harbors 6 fish families (Protopteridae, Notopteridae, Cromeridae, Nothobranchidae, Anabantidae and Channidae) which have not been described from the other basins. The Gibe-Omo and Blue Nile basins have more or less comparable species richness. The former was reported to harbor 76-79 species in 42 genera and 20 families and the latter has 77 species in 37 genera and 16 families. Similarly the Tekeze and Shebele drainage basins are comparable with 34 species (in 22 genera and 10 families) and 33 species (in 21 genera and 12 families) respectively. Families Anguillidae and Gobiidae have been described only from the Shebele system so far [22].

Endemicity is reported to be highest in the Blue Nile drainage basin and it is less in Baro-Akobo and Gibe-Omo basins despite their highest fish diversity. The highest species endemicity in the Blue Nile basin again could be attributed to the high cyprinid endemicity (about 18 species) reported for the Lake Tana [23]. The high endemicity in Lake is probably due to the geographical barrier formed by the Tis Isaat Fall that effectively isolated the lake fauna from the lower part of the Blue Nile basin. The Wabe Shebelle system within the Ethiopian territory has also been reported to have some 10-12 endemic species. The lower species endemicity in the otherwise high species diversity basins (Baro-Akobo and Gibe-Omo) could be due to the lack of sufficient exploitation capture possible endemicity. Ethiopian endemics are so far represented by a few species such as *Danakilia franchetii, Nemacheilus abyssinicus, Garra makiensis, Garra ignesti* and a large number of *Labeobarbus* species [1]. Some of the commercially important species in the country include *Oreochromis niloticus*, *Labeobarbus* spp., *Lates niloticus*, *Clarias gariepinus, Bagrus docmak*, and *Cyprinus carpio.*

3. Current Status of Capture Fisheries

Capture fishery is the capture of usable aquatic organisms from the wild. Such is the case of Ethiopia that apparently all the fish consumed in the country are collected from the wild using artisanal methods. The major consumable fishery resources to the big cities and towns in Ethiopia are captured from the rift valley lakes (40%) and Lake Tana (50.2%) in the north [40]. The Ethiopian Rift Valley contains a chain of small to medium-sized lakes, a few of which are saline. The most highly productive lakes where regular fishing conducted are Lakes Ziway, Langano, Awassa, Chamo and Abaya. In addition, fishing is highly practiced in two large reservoirs, namely, Fincha and Koka. Riverine fishing activities, mostly for local consumption, are performed in Baro River and its tributaries (located in Gambela and Benishangul Gumuz, south western Ethiopia) and the Omo River systems, going as far as the Kenyan border [11].

3.1 Fishing gear Technology: Gears commonly operated in Ethiopian fisheries include gillnets, beach seines, long-lines, hook-and-line, and cast nets. Various forms of traps, scoop nets and baskets made of plant materials and wires are also used, particularly in the rivers of Ethiopia [12]. Gillnets are used almost on all Ethiopian lakes and account for most of the commercial production. Beach seines are used for commercial catches in the northern Rift Lakes such as Ziway and Langano and Koka Reservoir. In Lake Abaya both the bottom and surface longlines are used to catch *Bagrus* and Nile perch, respectively. The latter is also used in Lake Chamo to catch Nile perch. The use of hook-and-line is often restricted for subsistence fishing. Many other traditional gears are also employed on various lakes and rivers of the country's drainage basins. For instance, scoop nets in conjunction with fences are used in Gumara River of Lake Tana. The traditional gears particularly account for most of the fisheries in Baro-Akobo Basin in Gambella region. Moreover, there are uses of poisons, extracted from various plant types including *Millettia ferruginea*.

3.2 Fish Production: The current total fish production potential is around 51,481 tonnes annually (Fig.1). Since 2000, actual production has ranged between 10,000 to 15,000 tonnes, and has since the 1950s (when Eritrea was part of Ethiopia and when marine fishery was possible) fishery production has never exceeded 20,000 tonnes. Data collection often lacks consistency and uniformity at all landing sites [11].

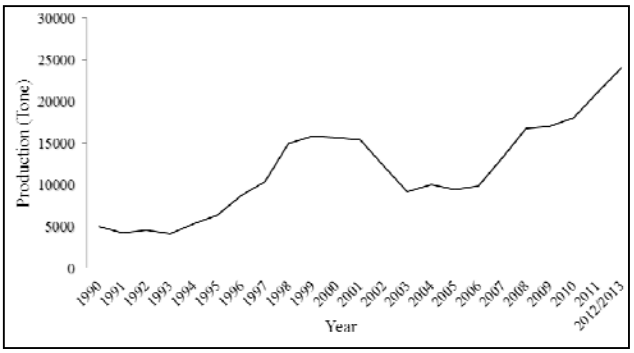

Fig 1: Total fish production from 1990 to 2010

3.3 Fish Health: Maybe one of the factors that hinder fish production is disease. According to [30], apart from loss of post-harvest production, diseases are known to cause mortality both in aquaculture and capture fisheries and some are also causes for human diseases in many areas of the world. It must be noted that most parasitic diseases occur as a result of poor water quality. Most parasitic organisms are opportunistic and may be present all the time in the tank or on the fish in low numbers, and only cause disease when the fish is stressed. The amount of fish present in a tank, the water temperature, pH, lighting, type of filtration system and water

chemistries all influence the health of the fish. Since research is the base to undertake intervention measures many studies have to be conducted in this area for the future. However, there are a few reports concerning fish health in Ethiopia [30, 18, 39, 38].

In general, in Ethiopia fish are not serious human health problems but, they are important in relation to aquaculture development. There are some risks to public health in a badly managed culture system. Therefore, based on these facts some studies are conducted to control fish disease to avoid the above risks, to prevent costly losses in production from aquaculture, to prevent transmission of diseases among culture systems when eggs or larval fish (fry) are transferred from culture to a new area and to prevent hazardous effects of a disease control measures if treated fish are sold as food.

3.4 Preservation and transportation: Fish is one of the most perishable foods, particularly in tropical climates of less developed nations [7]. If proper care is not taken immediately after capture, it can be spoiled in a few hours. Even using traditional methods fish can be still subjected to various forms of spoilages [14]. Fish handling in Ethiopia is at its lowest level and remains at its traditional stage. Starting from the collection of fishes from the net or hooks, fish are thrown on the floors of boats, canoes or rafts.

Most of the fish catches from the lakes reach the market by traditional means of transportation without any preservation facilities. Some fishermen hook some of the fish together with a string and carry them by hand to the market for immediate cash income. Others put the fish in a basket, cover them with fresh leaves and carry them by hand. Still others collect their catch in sacks and carry it to the market by hand or on donkeys, taxis or Pickup trucks [33]. The most common forms of fish storage is the use of deep freezers of varying sizes and cold rooms in some cases such as the FPME fish collection centers at Arba Minch, Bahir Dar, Zwai and Addis Ababa. All the shops of the same Enterprise in different towns and cities have mostly deep freezers and in some rare shops cold rooms as well. It should, however, must be realized that all these fish storage facilities do not get regular supply of power to keep the freezers and cold rooms running around the clock. Most fish retail shops and fish collection or storage facilities do not have backup diesel generators [11].

Although Ethiopian consumers have preference to whole fresh fish, traditional drying of fish is performed on remote fishing sites. Sun drying is the simplest way of preserving fish and is practiced to some extent in some rift valley lakes. Salting as a preservation tool could be best used in areas where salt is available and cheap [13]. Smoking is not a traditional method and only some trials have been carried out at the Fishery Production and Marketing Enterprise (FPME) receiving station at Zwai [28].

3.5 Fish consumption habit: Ethiopians do not consume large quantities of fish, although there is no religious prohibition for the Christian and Muslim populations. Rather, this is a country with a strong tradition of livestock rearing and meat consumption. The Ethiopian Orthodox Church observes several fasting periods as well as fasting days every week, when meat is not consumed. Most Christians consider fish acceptable during those periods, though some strict followers will not eat any animal products [11].

These factors give rise to some particular characteristics of fish consumption in Ethiopia. Overall, per capita fish consumption is very low (perhaps as little as 200 g/year-based on the population and production.) [24]. However, consumption is heavily biased towards quite limited geographical areas and also heavily weighted towards fasting days (Wednesdays and Fridays) and fasting periods (55 days in March/April, 15 days in August, as well as other periods which may be less widely observed). Increasing scarcity (apparently reflecting both rising demand and supply constraints) has resulted in rising real prices for fish, so there is an increasing tendency for fish to be a luxury product consumed by higher income groups.

3.6 Fish marketing system: Substantial potential fish marketing system exists in Ethiopia, that its present weakness is not the lack of demand but the absence of fish trading tradition and an inefficient marketing network [21]. According to [1] most Ethiopians prefer beef to fish even though it is much more expensive and hence not easily obtained. Fish marketing in Ethiopia is also influenced by many factors most of which are common to many under developed countries. These include poor transportation and preservation facilities. In addition to these selectivity of people to some species have also been found to harm the marketing situation [21]. Fish price is determined by the demand and supply condition of fish in the country. The buying and selling price of fish by the fish producers and traders has increased from time to time. The price of a kilo of whole fish almost doubled within five years of time for instance in L. Tana. And the selling price of filleted fish has increased almost by three fold. But now a kilo of whole and filleted fish ranged from 15-20 Birr and 65-85 Birr, respectively including in rift valley area and even more than this in Addis Ababa.

Cost of production for a kilo of fish varies from season to season depending on the availability of fish around fishing areas. In seasons like July to September and February to May production reaches above the mean. Peak production occurs during July and September, mainly during August and the cost of production during this season drops. Hence individual fishers as well as cooperatives fetch large benefit in this season. But in the other seasons the amount of produce dropped below the mean to the extent that no fish has been caught in some months of a year. During these period fishers, mainly commercial ones, lose money and stop fishing.

4. Current Status of Aquaculture

Aquaculture, also known as Aquafarming, is the farming of aquatic organisms such as fish, crustaceans, mollusks and aquatic plants. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions. Aquaculture in Ethiopia dates back to 1955, when a few extremely small experimental ponds were constructed at Dukam (40 km south of Addis Ababa) for growth observations and introduction of *Tilapia zillii* into Ethiopia (Brook Lemma 2008). Recently, regional research institutes, agricultural bureaus and farmers associations that do water harvesting for irrigated agriculture are showing interests to integrate aquaculture into their farms [31, 16, 5, 41, 2, 27]. Given this scenario, aquaculture could be quite feasible in Ethiopia, given the diversity in climate, and the availability of aquatic systems inhabited by over 180 fish species [17].

In recent years, as capture fishery is in constant danger due to illegal and overfishing, the Ethiopian population is increasing putting more pressure on food security and irrigated agriculture and water harvesting in dams continue

aquaculture, has started to emerge as a possibility in the minds of experts in the field that can supplement the food production system of the country. As a result, administrative regions such as Tigray and Amhara Agriculture Bureaus have made concrete plans to include aquaculture components into irrigation projects [7] including Oromia administrative region that raised in different systems like water based (cages), Land based (Ponds) in Mono culture and Poly culture system. In addition, Integrated Aquaculture-Horticulture and Integrated Aquaculture-Horticulture-Livestock started to scale up in some areas of the country in which the by-products (wastes) from one component are recycled to become inputs (fertilizers, food) for another.

4.1 Potential Culture Fishes: A number of factors need to be considered before deciding on species for use in aquaculture. The standard criteria for evaluating the aquaculture potential of species relate to a number of characteristics such as growth rate, yield and market value (Hecht and de Moor 2005). In the main, aquaculture species on which to concentrate as economic sources of protein would be those species which are fairly popular as food, low on the food chain, hardy, easy to culture and fast growing. Among the local species found in the country, species known as having a good breeding potential are *Oreochromis niloticus, Sarotherodon galilaeus, Heterotis niloticu*s and *Clarias* species (Breuil 1990). Similarly, tilapia, common carp and *Clarias* species from among different species as the most important species for aquaculture in Sub-Saharan Africa [25]. In Ethiopia Nile tilapia, *Oreochromis niloticus, Clarias gariepinus* and Carp species are most common.

4.2 Potential fish feed: Fish feeds play a major role in aquaculture viability and profitability, because they account for at least 40-60% of the total cost of fish production [37, 15, 29]. Although there are rooms for enhancing aquaculture production in Africa through improvements in the overall production system, in genetics and general farm management principles, the desired growth of aquaculture which is necessary in order to meet the increasing demand for fish is only achievable through cost-effective and high quality fish feed [20]. Locally produced feed reduces the cost of production and hence, cheaper means of meeting the protein requirement improve food security and reduce the level of poverty in developing countries, thus inexpensive and locally available feedstuffs are to be identified. The search for alternative protein sources is to be focused on by-products and materials which are not suitable for direct human consumption [26]. However, in Ethiopia a number of by-products from agricultural processing are available, which are usually not utilized for human consumption, but may have a high potential for small-scale aquaculture. It is anticipated that the transformation of locally available by-products low in protein into high quality fish protein, can be a major contribution to improving the protein supply for the local human population.
Several agricultural and agro-industrial by-products available in Ethiopia have been evaluated for their production potential in poultry and livestock feed [9, 32, 3, 36]. However, only some information is available which cover the suitability of this resource for fish feed [8]. Hence, the presence of agriculture is an important indicator of aquaculture potential in the country, because it is a source of by-products for fish feed or fertilizer. For small-scale fish farming, agricultural by-products can contribute to higher yields than would be possible from the natural production of the pond. For commercial fish farming, use of by-products from agriculturally produced industrial food processing can reduce feed costs by allowing replacement of part of the formulated feeds [6].

5. Efforts Made in the Fishery Sectors

5.1 Institutional/management arrangements: The Ministry of Agriculture (MoA) is the key ministry for fisheries issues including the Institute of Agricultural Research of the country (National as well as Regional). MoA is responsible for the development and management of the fisheries while research centers and universities undertake research in response to fisheries management and development needs. Ample amount of technologies and information were generated from Universities and research Centers for sustainable utilization of the fishery resources. From those Farmers start integrating pond fish culture with vegetable production and poultry through the effort of Zwai Fishery Research Center; In some areas of the country nursery sites are established and they have started hatchery process; different locally available agro-processing by-products important for small scale fish culture were identified; The effect of stocking density and supplementary feeding on growth performance and yield of fish as well as effect of feed quality on growth performance and water quality in cage culture system for production of fish were identified; effect of feeding frequency on growth performance and survival of fish in a cage culture system were identified; and evaluation of Aquaponics are under way at Ziway Fishery Research center and Debre Birhan through Addis Ababa University is an encouraging job. In addition to these different fishery technologies are scaled up to the farmers.

5.2 Policy and legal framework: Proclamation No: 315/2003, namely, the Fisheries Development and Utilization Proclamation is the principal legal tool available to the Federal Democratic Republic of Ethiopia for the management of fisheries. Based on this proclamation, two regional governments (Oromia and Amhara) which have major fishery water bodies produced their own respective proclamation for management of fisheries under their jurisdiction. Although there is currently no fisheries policy document in Ethiopia, a range of national development documents identify fisheries as being a sector in need of support to enable it to increase production and contribute to the food security of the growing population.

5.3. Investment in the sector: Some investors have started to show interest to develop aquaculture in Ethiopia and there are now four private enterprises that are licensed for the same. These are: (i) The Ethio-Fisheries Private Limited Company that built a fish processing plant in Arba Minch, near Lake Abaya, (ii) Vittoria Viezzt Carlo Talaric PLC which is planning to initiate fish farms along the shores of Lake Chamo, (iii) MIDGE 2000 PLC Cage Culture and (iv) Ashraf Industrial Group Cage Culture, both planning to operate on Lake Tana. There are also two crocodile farms in Arba Minch, one governmental and one private that raise crocodiles manly for skin export [11].

6. Conclusions and Recommendations

Ethiopia's extensive inland rivers and lakes contain substantial proven reserves of fish and other aquatic resources. But this potential is not exploited to its capacity.

There are several reasons attributing to the low production among which the age-old fishing methods, economic backwardness, adverse religious practices, inadequacies in transportation and preservation technologies. There are no laws and regulations for productive utilization of fish resources and protection of catchments or abating land aquatic vegetation degradation around the lakes. In addition to these fishing in Ethiopia is constrained by lack of efficient infrastructure and marketing network. The infrastructure at fishing sites is undeveloped and inadequate and is devoid of transport facilities to link remote water bodies with major consuming areas. Harvesting and processing technologies are not accessible, thus limiting the scope of marketing to the nearest local outlets where fish can be sold fresh immediately after catching. Inadequate extension services and lack of credit for the purchase of fishing tools have constrained the production capacity of fishermen.

Generally, this review indicates that vulnerable freshwater ecosystems are not well exploited, due to several reasons. Therefore, we have to take immediate actions and every possible measure to tackle bottlenecks so as to realize the contribution of their resources to the food problem of the country. Hence, the issue of appropriate management is an urgent need to address the contribution of the fishery as a source of food, income and employment. This can be done either by the government or by the fishing communities themselves or by both and need to follow strictly the following management options: The contribution of the untapped fishery resource to the food problems of the country must be realized as soon as possible, if the country's policy of food self-sufficiency is to meet its desired end. This involves an updated and comprehensive resource assessment supported by sound policy that guides the development of the sub-section; gear restriction such as mesh size regulation, catch limits, closed season or area is the most common regulatory measure used by the local fishery officer; fishing instrument including gears and boats used in most of the water bodies are developed through experience and the practical exercise of artisan fishermen and hence a lot of labour and time is required to operate and mend them. So, every possible measure should be taken to replace them with modern improved and user friendly gears.

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