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Traditional Gillnet & Motorized Fisheries in Ethiopia and Loss of Biodiversity in Lake Tana (Its Implication to Food Security)

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Abstract

Lake Tana is found in North West of the country & it is the biggest lake in the country. The lake is with higher potential & with unique fish fauna barbus. The fishery has started to develop with the help of foreign NGO's. However, fish exploitation does not exceed 1500 ton per year. On the other hand, different studies & including this paper have shown that the catch is declining since 1997/98 in the inshore. This is because of social, economical & institutional factors.

According to the secondary data & survey conducted, the lake is contributing to livelihood 3457 people of the surrounding people in different ways. However, the policy of the region is maximum sustainable yield but in practice it is an open-access (un controlled fishing activities). As the study shows considering the inshore the actual harvest is above the optimum catch in both motorized & reed boats. There is loss of biodiversity of the fishery due to the above mentioned factors. Therefore, the fishery management should use strategy which brings the fishing to the level of optimal by using command & control & economic incentives. The first one refers to licensing, gear restriction and close specific season etc & the second one refers to giving credit & tax imposing tax for in shore and minimum tax for offshore.

Therefore, greater attention should be given in managing & appropriate use of there source before the stage of extinction reached. If it reaches extinction the socio-economic livelihood of the surrounding will be suffered. This leads to food self insufficient.

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ACRONYMS

- A.A.U---------------------------- Addis Ababa university
- Birr------------------------------- Name of local currency which exchange rate is 1USD=8.67
- CPUE------------------------- Catch Per Unit Effort.
- ICAD--------------------------- Inter Church Aid Department
- EOC---------------------------- Ethiopian Orthodox Church
- FAO STAT-------------------- Food And Agricultural Organization Statistical Database
- FAO---------------------------- Food And Agriculture Organization
- FPME-------------------------- Fish Production And Marketing Enterprise
- FPMC-------------------------- Fish Production And Marketing Corporation
- ICFE ---------------------------- Inter Church Foundation Ethiopian from URK
- FRDD ------------------------- Fisheries Resource Development Department
- L$ ------------------------------ Local Currency
- LFDP--------------------------- Lake Fishery Development Project
- Msy------------------------------ Maximum sustainable yield
- NGO'S-------------------------- Non Government Organization
- SSFDP--------------------------- Small Scale Fishery Development Project
- USD------------------------------ United State Dollar
- Wp25---------------------------- Working paper 25

1. INTRODUCTION:

1.1 Background

Ethiopia is a land locked[1] country since 1993. It has total area of 1, 235,000 Km2 and according to 2002 statistical estimate, the population of Ethiopia is about 67.5 million, which is growing at 2.64% p er a nnum. E thiopia t herefore s tands a s t he f ourth l argest i n a rea & t he s econd l argest population in sub-Saharan Africa (world fact book 2002).

Ethiopia is rich in human & natural resources, with 48% of the actual productive labour force & its arable land constitutes 16% of the total area .The country is rich in livestock & other mineral resources. However, only 15% of the agricultural potential is utilized & the contribution of the mineral resources to GDP is limited to 2%. On the top of that, the country is suffering from frequent drought and poor cultivation practice. Therefore, the condition places the country as one of the poorest and least developed countries in the world.

Despite this fact, however, the economy has been grown in the past few years. In 2001 the economic growth rate was 7% that contributed about $46 billion & the per capita was $700. GDP is composed of agriculture, industry and services which is about 52%, 11% & 37% respectively (world fact book, 2002) Lake Tana is the largest Lake in Ethiopia. It has a big potential of fish for the country. According to Demessie S 2003, the Lake is giving life for 3,400.00 People as a primary source of living. However, the multifunctional way of L ake Utilization together with uncontrolled fishing activities, limited Production efficiency and distribution mechanism, as well as other socio -cultural and Economic factors are threatening the fishery in different aspects. As Ethiopia is the poorest country in the world, most of her people's depend on Natural Resources, Forest, Water, and Fish like in Lake Tana. However, greater attention should be given to our resources before the stage of extinction reached.

Fishery in Ethiopia has contributed total gross sale of L$13.2 million or 1.55 million USD[2] in year 2000 at producers price averaging 0.82 birr per kg of fresh fish of the common species in the landing: tilapia, catfish, labeo & Barbus including others little contributing species (FAO STAT database, 2002).

[1] Ethiopia became lamd locked country on May 1993 at the time of separation of Eritrea from Ethiopia.

However, under new economic policy the principal objective of the agricultural policy including fisheries, are to ensure adequate food security via increased production, increased employment & improved income distribution.

1.2 Problem Statement:

So far, the study conducted on Lake Tana fishery are revolving on biological aspects except few studies like stock assessment and fisheries management by Wudeneh T(1998), socio-economic by Ashine S (1998), development & management approach by Aragaw C(1998), socio-economic survey study by LFDP (1993) & drewes.Therefore, no one has approached this Lake Tana fishery by optimum harvesting strategy approach.

From many studies indicated Lake Tana is an open access[3] resource. Specially, constrained by seasonality of demand, limited market, poor infrastructure, lack of credit, poor extension, research service and shortage of expertise. Regarding the regulations & management actions, no restriction of fisherman, fishing gear, no measure is taken, no management tools are exercised. Illegal fishing like toxic plants & chemicals have been rarely used in the river & river mouths (Gumera & Gilgel Abbay for example), no strong action has been taken by government offices except in this year the directives & rules of fishing are expected to come near future.

The contribution is to review fishing in Lake Tana & it should be optimal harvesting strategy and its implication should address to food security. Factors contribute over fishing are (theft of net) or shortage of inputs have contribution to over-fishing migratory Barbus. This has led to loss of fish species.

Weakness of the LFDP projects (limitation)

I. The project did not mention which tool is appropriate to which lake.

II. The other weakness is also that the projects objectives were to achieve maximum sustainable effort (EMSY). However, this days this strategy does not consider efficiency and sustainability and if Msy is over estimated, MSY will lead to over-exploitation.

[2] USD- Exchange rate at that time was about 1USD =Birr 8.54.

[3] In Ethiopia context open-acsess when there is no property right that is the property right and the management are not determined. Every fisher man who wants to fish can fish from the lake without restriction.

Issues that need to be addressed

I. To identify the optimum solution of fish resources.

II. Causes for deviation from optimal solution in traditional fisheries and motorized fisheries.

III. What are the causes for inshore fishing?

IV. What are the institutional problems?

V. Poor infrastructure

VI. By how much the amount of the stock should be utilized in most profitable way.

1.3 Objective

The purpose of this Paper is to curb over- fishing or depletion of fish species by using optimal harvesting strategy .To identify the deviation of optimum from the actual harvesting and to assess the causes of the deviation. It will also consider institutional structure of fishery on influencing loss of bio diversity. It also looks in identifying alternative policy.

Specific Objectives:

1. To Estimate the optimum, free- entry and maximum sustainable yield (MSY) harvest solutions for traditional and motorized gillnet.
2. Identify the causes for deviation the actual from optimum harvest solution (institutional structure).
3. To assess the economic factors that affects the fish harvest.
4. To analyse the influence of traditional and motorized fishing technology on loss of fish species.
5. To identify policy option to sustainable utilization of fisheries and protect loss of fishes.

1.4 Research hypothesis

The characteristics of fishery is as the level of effort rises, it initially increases output, but later an increase in effort will lead to fall in the level of out put. In such a case there is a maximum sustainable catch which the harvested population can provide. The other character is that the level of effort depends on the nature of property right of the fishery industry. When fishing is an open access, the bio economic system will be over exploited beyond the Msy level (bedding ton 1990).

2. Theoretical and empirical review

2.1 Theoretical Literature Review

Although fish may not be the first environmental resource, that the world's fishery resources are important for several reasons. Fish are a major source of protein for a large portion of the world's population. Even though fish are a renewable resource, they are destructible. Over exploitation and environmental change such as pollution & loss of wetlands, threaten this important resource. Populations of many important species have declined markedly in the last several decades. Causing h ardships for fishing c ommunities a nd lowering the q uality o f life o f p eople w ho g et benefit from fishing. For example, in developing nations, commercial fisheries are in conflict with those fishing families who fish solely to feed their families and as fish stocks decline, the ability to feed their families has been seriously compromised. these conflicts make the development of fisheries policy even more difficult. (J.R. Kahn, 1998).

There are several important anthropogenic causes of extinction. These include excessive harvesting of the species, loss of habitat and competition from non-native species. All of these causes stem from market failure, where people make economic decisions that do not incorporate full social costs of their actions. Biodiversity promote ecosystem stability. The more diverse a system, the greater its ability to with stand shocks and stresses. Many people desire biodiversity, deriving greater utility form more diverse ecosystems than less diverse. (J.R Kahn, 1998, Tietemberg 1992).

Fisheries resources has been viewed as capital stock that can generate considerable and sustained social and economic benefits if managed properly. The fishery sector plays a significant role in food security through the supply of food for developing countries as a whole. Fish currently makes up about 19% of the total animal protein consumption, or just over 5% of protein from both animal and plant origin (FAO, 1995 and 1997). In this respect and more importantly in response to increasing population the exploitation of the food resources existing in the sea, rivers and lakes has received special attention (Girard M.J 1968).

Biodiversity is a fundamental to the functioning and resilience of fresh water ecosystems because they supply goods and services that are important for human welfare. However, economic utilization of such system may lead to biodiversity loss either directly through over exploitation or indirectly through habitat destruction. The basic problem of biodiversity conservation is to maintain that level of biodiversity guarantee the functioning of ecosystems on which human consumption and production depends (Barbier et al, 1995), perrings, C.K Maler, al 1995).

The main cause for biodiversity loss is human activities. It is significant to distinguish the proximate causes including direct exploitation of species for example through hunting, fishing & collection or gathering and their direct impact on ecosystem degradation that leads to species loss. Habitat destruction & conservation can be given as examples Underlying causes comprise the economic, social -political cultural factors that lie behind the activities that lead to direct depletion of species and degradation that leads to species loss. Habitat destruction & conservation can be given as example-underlying causes comprise the economic, social-political cultural factors that lie behind the activities that lead to direct depletion of species and degradation of their habitat. These includes growth of population, culture & ethics, economic incentive, policies & institutions (Barbier et al. 1995; Heywood, V. and R .Waston 1995).

Maximum sustainable yield is not efficient because it is related with maximizing net benefit from the use of resource. If we are to deal with the efficient allocation, we must include the costs of harvesting as well as benefit. Efficiency implies not only that the catch must be at the efficient level but it must also be extracted at the lowest possible cost. (Tietemberg , 1992).

Open access fishing is the process of rent dissipation. As FAO(1995) pointed out open access always enables the economic activities of one agent to affect another in the sense that additional fishing effort entering a fishery causes a fall in catch and higher cost for those who already in the fishery. This leads to conclusion that an open access with out carefully designed fishery's management system the fishery is likely to become a drain on the economy rather than a net contributor to it (Palfreman D.A,1991).

The Idea of optimum control theory emerged because maximum sustainable yield (MSY) is unstable; the slightest over estimate of MSY can lead to depletion or extinction of the resource. MSY is not actually or sustainable over long run, because of natural fluctuations in the resource stock. If MSY is allowed to be harvested in years when x is at a naturally low level, the resources may be seriously depleted. In addition MSY completely ignores all social and Economic considerations of renewable resource management. (CONRAD. J.M & C.W.CLARK 1994.)

One of the economic incentives that solve environmental resources is to entitle appropriate property right. It has been observed that the assignment of the correct property right will lead to the achievement of desired conservation policies by the parties exercising those rights. The assignment and enforcement of property rights is essential to facilitate any allocation of resources by all parties involved. In the assignment and enforcement of property rights is a way of the institutionalizing ownership of resources (Starret, 2003).If a village is assigned a management area, each village has an incentive to manage its resource as a long-term asset. Therefore, fishing to extinction would eliminate as a long run source of food.

According (Tietemberg, 1992) one kind of policy is to design quota on the number of fish that can be taken to the fishery. There are many types of quota but all do not have equal merit: 1) The quota entitles the holder to catch a specified weight of a specified type of fish. 2) The total amount of fish authorized by the quotas held by all fishermen should be equal to the efficient catch for the fishery and3) the quotas should be freely transferable among fishermen.

There are different views of points on the definition of fisheries management objectives; however, the aim of fisheries management is not primarily to maintain the stock but make best use of the resource in the terms of larger and cheaper supplies of fish to consumer and better income to the fishermen (Schmidt, U. 1968).

The objective of rational management, therefore, is to institute regulatory measures before the over fishing stage is reached rather to use regulation exclusively to salvage a fishery that has becoming over fished. A complementary definition is given by Pomeroy R.S and Williams M.S (1994:p3), the primary concern of fisheries management should address the relationship of fisheries resources to human welfare: and the conservation of the resources for the use by future generations. That is the main focus of fishers management should be people not fish per se". In totality a fishery needs to be considered as a stock of fish and the enterprises that have the potential of exploiting them. For the former , its size the growth rate, and for the later, total fishing effort and catch and costs and revenue associated with them are crucial variables that need carefully to be controlled and optimized(Anderson,1982). In fact, even though there are different view points to define fisheries objectives Panayotou(1982) came up with a agreeable proposition that the general objective of both management and development is an attainment of the optimum rate of exploitation of the fishery.

2.2 Empirical Literature Review

Empirical evidences suggest that most of the depletion or loss of fish species are from habitat destruction, interruption of migration routes and the introduction of exotic species. But fishing involved in few cases. However, it does not mean it is unimportant for continuous over exploitation of fish. On the other hand, fishermen have been the cause for over fishing and depletion of the population by over fishing in the sense that over fishing causes reduction in the size and age of fish in the catch, and changes in the genetic structure of the stock (Robert & Polumin 1993).

Henderson and Tugwell (1979) analysed the optimal and free market utilization of lobster fishery in two fishing areas in Canada port Mait land and Mininegash. They estimated both the growth function and the production function. Using these estimates the authors calculated the stationary value of both the free-entry and profit maximizing solutions. It was noted from the results that free-entry solutions for both catches & stocks and the actual solutions in the two area were similar. The model, therefore, predicted very well. It was also noted that although the free-entry solution had higher catches, the associated efforts was much greater because the equilibrium stocks were smaller. Free entry did not lead this fishery to ruin but it did reduce the net benefits of fishing to all those in the industry (Hendrson and Tugwell, 1979).

Another instructive study by Gallastegui (1983) considered the management of the sardine fishery of the gulf of Valencia (Spain). Using data that described the fishery exploitation, optimum levels of catch effort, and stock were calculated. In addition ,the Welfare gains that could be achieved by a movement from the open-access equilibrium to the social optimum solutions were demonstrated. The results of the study showed that Sardine catches were above the Msy over the period of study (Gallastegiu, 1993)

Therefore, no one has approached this Lake Tana fishery study by optimum harvesting strategy approach. The paper will estimate the optimal solution for traditional fishers and motorized fisheries (cooperatives) and will identify the deviation from the actual harvest. In addition, it will try to identify the causes for the deviation. And tries o identify in which of the two group fisheries is more exercising of loss fish species. In addition, the loss of bio diversity may be studied by using simpsons index and Shannon weiner index. In general, the paper concentrates how to use the fish resource sustainability at its steady state position without affecting the fish stock using optimum harvesting strategy.

3. OVERVIEW OF THE ECONOMY AND FISHING

3.1 CONTRIBUTION OF FISH TO THE ECONOMY OF ETHIOPIA

Ethiopia is located in the Horn of Africa and its water area is approximately 7400km square of water bodies plus 7000km of rivers. The population is estimated to be 65,344,000(2001) and GDP at that market price was US $6061 million and agricultural GDP(2001) was about US$2728 million(FAO,2001).Fish for direct human consumption 15,390 ton was produced and 35.58 ton(US$78,056) was imported and 54.19 ton($US 107,918)was exported(Ethiopia custom authority,2001).

From the estimated employment (2001), in primary sector the total fishermen estimated at 15,000, of which about 5000 are active and remainder are part time and occasional fisheries. Of the total full time fishermen, 2790(55.6%) are organized into cooperatives or peer groups. whereas, in the secondary sector: about 20,000 people are estimated to engage in ancillary activities of the commercial (lake) fisheries. In addition, the gross value of fisheries out put (at ex-vessel prices)(2001) was about $US 3,563,000(calculated at $US1= birr8.56)(MOA,2001).

Based on a systematic assessment of lakes and on length based empirical model for rivers, current annual total fish production potential is estimated to be 51481 tones. In2001, total landing were estimated at 15389 tones which is about 30 % of the calculated potential. Between. 7700 and 16224 ton. Despite this fluctuation, it has grown on average by 10% per year in that period. Current per capita fish production is less than 240 g per person per year. But it is more than double the level of the early 1990s. Success in fisheries has been attributed mainly to a favourable economic policy, which attracts private sector participation and project assistance in the fishery sector.

Fishery is dominated by artisanal currently involving 15000 fishers (of which 5000 are considered full-timers). Fishing from 2342 boats (366 motorized steel or wooden vessels, and the rest are reed or raft vessel), with some 17240 nets and 28000 hook gear in use ranges from a variety of traps and spear gillnet and beach scene, and hooks on hand & long line. Motorized fishery is typically for Lake Tana. Primitive locally produced wooden boats are common in Lake Koka, Ziway and Langano. The use of gillnets and hook gear is widespread in the country's water bodies.(FAO,2002).

3.2 Utilization of fish in Ethiopia

Fish is utilized in fresh, chilled, frozen & canned form. Much of the fish is prepared into gutted & filleted forms at landing sites. About 73% of the total fish landed is marketed fresh near by markets. The remaining percentage goes to distant consumers either chilled or frozen or as dried, smoked & canned forms. Nowadays, canning has stopped due to poor product quality & weak demand (FAO, 2002).

The private & public sectors of fish are working in competition after 1991. The share of public sector has fallen drastically to about 8%. Those legally participating in the commercial firms have chilled & frozen fish products & use refrigeration facilities during storage & transport. On the other hand there are also informal traders which frequently came during peak demand & distribute fish with poor hygienic conditions.

From the very nature of Ethiopians, they eat meat but now a days eating habit of fish is increasing where there is regular & sufficient supply of fish. On those area fish consumption is greater than 10kg/person. This shows that fish consumption is more influenced by supply factors than by culture.

3.3 Aquaculture in Ethiopia

Aquaculture in Ethiopia is more potential than practical, but the country's physical and socio-economic conditions are favourable to its development.

Since 1975 the Sebeta fish breeding research centre, has been practiced extensive aquaculture in the form of stocking and enhancing artificial lakes, reservoirs and small water bodies. In the period, over 2.5 million fingerlings, primarily consisting of Nile tilapia.(Oreo Chronis Niloticus), Tilapia Zilli and carp, have been released, but in the absence of systematic monitoring and evaluation (due to weak institutional capacity) the success or failure of the program is unknown.(FAO,2002).

Aquaculture is recognized as alternative means of achieving food security and poverty reduction in the rural area, and is now considered an integral part of rural and agricultural development policies and strategies. However, many remain to build institutional capacity in the areas of research technology and training. With the new policy, farmers are building new small bonds therefore the government is expected to focus in introducing fish farming.

3.4 Demand & Supply of fish in Ethiopia

3.4.1 Demand of fish

Even though, the current per capita is less than 240g. Based on a single facto - population current annual demand for fish in the country is estimated at 65,544 tones, equivalent to 1kg/person. The future demand at the present population growth rate will reach 83,483 tones in year 2010, 94,526 tones in 2015 & 1171586 tones in 2025 respectively. This is minimum demand, since factors other than population are not considered here (FAO, 2002).

3.4.2 Supply of fish

The country has an estimated annual total exploitable fish potential of 51,481 tonne, which can meet only 79% of the current actual demand, 55% of the projected demand in 2010, and 44% of the projected demand in 2015, based solely on population size. In view of this, the present water bodies or fish supply sources are unable to meet the demand. This calls for an increasing focus on stocking & enhancement of artificial made water bodies & development of aquaculture. Encouragement of importation of fish products can be seen as a last resort, considering the objective economic realities of the country. The current low level of exploitation of the fisheries leaves considerable room for further expansion, with an estimated additional 36,000 tonne of fish is available for further expansion (FAO, 2002)

Ethiopians are meat eaters, with an average annual meat consumption of about 10 kg per caput. This is due to cultural patterns and, to a significant extent, to fertile control highlands which allowed considerable expansion of cattle breeding. In addition, the dominant Ethiopian Orthodox Church which encourages the eating of fish during fasting seasons had served to concentrate domestic fish demand with in two short period of the year totalizing about 80 days: two months between February and April and two weeks in August. In production areas, fish demand has been stimulated by regular supply of good quality product at an acceptable price, when compared to the prices of meat.

3.5 LAKE TANA AND DEVELOPMENT IT'S FISHERYIES

3.5.1 LAKE TANA AND IT'S DEVELOPMENT

Lake Tana is found in the northwest part of Ethiopia in Amhara regional National state. It is surrounded by north Gonder (NG), South Gonder (SG) and West Gojam (WG). The lake has an area of 3500km Square with a mean depth of 9 m. and a shoreline of 358km(LFDP.1997a). Approximately it is 85 km wide and 65km square long. There are four permanent rivers (Derma, Reb, Gumera and Gilgel Abbay) flow into lake and one out let, the Abbay which is known as Blue Nile River[4] (LFDP, 1997A).

The commonly fished species are catfish, Barbus tilapia and others. The Barbus is noteworthy because they may represent several species or even a unique cyprinid species flock. Fishing started relatively not more than 50 years as commercial activities. This situation came from a demand of fish created mostly form Addis Ababa and surrounding area of the lake and by upper and middle income class of Ethiopians.(Tarekegn, Wudeneh and Carlos,1998).Except on rivers flowing west to the Nile and the North Eastern, fishing is almost a men's activity. Women are rarely actively participating in fishing but they involve in local fish trading.

The development of the fishery has considerably benefited from external assistance NGOs such as the inter church foundation Ethiopia (ICFE), & the inter church **origination** for development cooperation (ICODO), have been active all over the country. Their most visible impacts are on the southern part of the Lake Tana which has been the development of the motorized fishery and improvement of the marketing structure mostly by attracting the fish production and marketing corporation (now enterprise FPME).

[4] Blue Nile river is the head stream of the worlds' longest river and home of the planets largest living reptile Crocodile (http://www.afircaguide.com).

A research component was carried out by the Wageningen Agricultural University. The EU has been the biggest donor. In the 1980,s, a first phase of the lake fisheries development project covered some of the rift valley lakes. It led to the introduction of improved fishing technologies and made survey of fish stock on two lakes (Ziway and Abbaya). It also improved its processing and marketing capacities.

3.5.2 STATUS OF FISHERIES IN LAKE TANA

Infrastructure like access to road is very poor in Lake Tana and surrounding. In some areas there is no even road. Only a single main gravel road connects Bahir Dar, Gonder Gorgora most of the consumption areas (town) are located over 15 km away from the lake. No feeder roads, except foot paths, that connect the traditional landing sites to the main road and hence transport barriers is crucial problem. Of the total 45 traditional landing sites (fishery office 1996), only two have important links to fish markets out lets.

Ethiopians eat fish only 150g of per head per year. However the demand is skewed to Bahir Dar Area and Gorgora northern extreme of the Lake. Prices of fish have shown small increase in the last few years but it is still around 1 birr per kg this could be due to cultural and religious factors and other factors. The other constraint it can be mentioned is that the budget allocated for research is insufficient though there are qualified staff members FAO (1995)

The current estimate of a safe annual production level is 15,000 tons per year provided an offshore fishery can be developed. A target of 4500 gillnets of 100m long with a minimum stretched mesh size of 8 cm is proposed. Licensing would be a demand unless any one of the following limit reference points is reached according to FAO 1995.

a) 18 cm as average length of tilapia in the commercial landings

b) 21 cm as average length of Barbus in the commercial landings or

c) 31 cm as average length of catfish in the commercial landings. There are indications that the Barbus morph types are already recruitment over fished probably due to the fishery or migrating spawners. It is therefore proposed to completely stop commercial fishing from the 7th of June to 10th of October, with in 5 km of the mouths of the major rivers and on the rivers themselves. Subsistence fishing would be allowed but only with a maximum of two hooks. Any fishing practice hindering the free movement of spawners on the rivers needs to be banned completely.

Lake Tana's yearly estimated potential was about 15,000 ton (FAO, 1995), LFDP (1996), Aragaw.C (1998) and Wudeneh T (19998). However, the highest landing recorded is about 1,500 ton in 1996/97. The product seems to decline because most the Reed boat fish in inshore but not due to decline its potential. The lake can be said that it is an open access to fishery and it is with many constraints like seasonal demand and poor fish eating habit, poor infrastructure, lack of credit, poor extension and research service and shortage of expertise.

3.5.3 THE CONTRIBUTION OF LAKE TANA TO SOCIO- ECONOMIC LIFE OF THE PEOPLE: TRADITIONAL AND MOTORIZED FISHERIES

The lake contributes for irrigation, electric power generation and fisheries development; and as a source of drinking water for both human and domestic animals and other economic development. In addition, the lake with its historic ancient monasteries and churches has a great potential for tourism and for investment growth. Furthermore, the lake contributes for poor communities as a source of food, employment and income. However, the population of the Amhara Region[5] grows 3% per year and estimated about 13.8 million, with 91% of rural and 9% urban people. The region is second in population next to Oromiya Region. 81% of the region is orthodox Christian, 18.4% are Muslim and 0.2% others. In the same year, the CSO, estimated the economically active population of the region is 7.7 million, of which over 1 %(or .078 million people) was found to be unemployed (CSO, 1994)

The domestic food availability on average was 70% and including imported cereals still was 76% of the recommend minimum per capital food intake for Ethiopia i.e 2,100 calories per day or 225.5 kg in cereal equivalent per capita food intake per year MOA 1995). Besides, in 1994, UNICEF (April 1994) indicated that about 6.7 million Ethiopian were in need of relief assistance, which amounted to some 895,500-ton of cereals & 733 t of supplementary foods. Therefore, this shows that how much the food shortage is available in the country.

[5] Amhara state region is one of the nine self administrative regions in the country that contains 10 administrative zones from which big administrative regions are found surrounding Lake Tana and covers 99 percent of wet land area (WACAI workshop, 2001).

Before actual fishing activity has started, the poor people (Weyto) living around the shore of the lake subsistence life was totally supplemented from Lake Tana & rivers that flow towards it, through hunting hippopotamus from the swampy margin of the lake; gathering roots and reed pith from the shore of the lake; and through fishing until early 1960's. It was also providing major economic activity for the Wayto people. Who have native knowledge of boat building from papyrus reed plant and navigation, through making ferrying activity using small reed boats (Tankua" in local language) (Abebe Z, 2001and Demessie 2003).Moreover, papyrus reed is favourable as a breeding ground for tilapia fish species. papyrus reed plant is found in the lake swampy area and near Blue Nile river. I t is also used as raw material for making basket, fishing boat (Reed boat) which covers 75% of the total vessel it is used as source of income. (Abebe Z. 2001).

Fish was used to be the main food source for the Woyto people[6] and poor communities living on the islands and surrounding the lake. It was the only food source for this group of people who have long tradition in eating fish & hippopotamus meat from hunting and subsistence fishing activities due to lack of access to farm land & unable to afford to use other food sources at previous time (Abebe Z 2001). The Weyto people were who started fishing in Lake Tana & rivers are still using fishing as means of subsistence. According to Demessie (2003) fish is found to be included as part of dish at least 1 or 2 days per week or on average of 146 days per year by each family of the respondents. The Reed boat fisheries produce on average 9 kg of fish per day. (2.03 USD/day).

The common practice of fishing is that fishermen set their nets in the late afternoon and haul early in the morning, with some exceptions where (in NG Zone) the net is left for 24 hours in the lake, being checked every morning (Tefferi, 1997). This practice is likely to contribute to the problem of pre-landing fish loss at that particular area.

[6] Woyeto people, who are minor ethnic group in the region, and who first started fishing in the lake, and even in the country. They were originally living scattered around the shore of the lake and now distributed in land around Alefa, Dembia, Fogera, Bahr Dar areas in the north, southern and south eastern part of the lake (Abebe Z.,2001).

Traditionally, Lake Tana fisheries consisted only of artisanal predominantly subsistence reed boat fishery. This type of fishery is limited to the shore areas and targets mainly tasty tilapia.

There are four major types of fisheries, each are characterized by specific combination of gears and fishing crafts. According to LFDP, WN, paper 16 fisheries statistical bulletin number 1. are as follows

1. The motorized gill net (mesh sizes 10-12cm) fishery based in Bahir Dar and part of South Gondar;
2. The reed rafts-gill net (mesh size 7 to 12cm) fishery
3. The reed rafts-gill net (mesh size 10 to 12 cm) fishery
4. The chase & trap fishery (gillnets with mesh size 7 to 9cm) fishery based in the southern part of the lake. Where as, the gears such as cast nets and traps are occasionally used but contributed little to the total catch & total effort.

There are four major type of fish species. These are as follows:

A) B arbus- Barbus intermedius

B) Tilapia - oreochromis nilotics

C) Catfish - clarias gariepinus

D) B eso - varicorhinus beso

3.5.3.1 TRADITIONAL FISHERY (REED BOAT) IN LAKE TANA

Reed boat carries normally only one fisherman. Gillnets are left in the water except when changing the fishing ground and for repairs. Catch is collected early morning at day break and sometime in the evening too. Chase & trap is also practiced rarely in the southern part of the lake especially during the time when the water level is low but contributes little to the total catch (LFDP, 1993).

Traditional Reed Boats use local gillnets hook and line traps and spear. The reed boats are 3-4 m long and 60-80 cm wide and have a life span of 2 months. They are made by the fishermen themselves using locally available materials. The raw materials are available in WG Zone & Fishermen from the other zones buy from this zone, LFDP. 1993).

The boat has limiting carrying capacity. On average it carries five nets each 50m long. Reed boats work in inshore only because they are not safe in deep areas. The money needed for reed boats using local & modern nets with (3 years lifespan) with a unit cost of Br 85. From social point of view, it is good for many people because they can join in the industry easily.

According to survey, most the traditional fisheries want to join the cooperatives. Assuming that they can get benefit from joining the cooperatives.

1) They know that they can get credit from the government

2) If they join the cooperatives, they can get motor boat. This time Reed boat fisheries are forming cooperatives associations but they could not get credit from the region. There fore, the informal fisherman tends to join the fisheries sector. If the government could give them facilities like licensing, giving credit etc. these may bring good controlling & minimizing the informal fishing.

Apart from Bahir Dar where the FPMc hold basic jetties, there is lack of landing facilities specially for Reed boat fisheries they are not equipped with electricity and fresh water supplies for fish handling and preservation. There are no installation (chill store, ice, freezing & cold store).

3.5.3.2 MOTORIZED FISHERIES IN LAKE TANA

The second is fishing using motorboats with 100m long multifilament gillnet having 10 to 14 cm stretched mesh size (L.FDP 1993). The programme of motorization was accompanied by the organization of the fishermen and with subsequent technical training in net making and engine maintenance. The nets produced by the workshop are sold to the cooperative members and non-members at the subsidized and any market prices perspectives. The Steel boat was chosen as a good boat for the fisheries development but further study should be done considering the poor fishermen. The motorized boat fisheries are found in west Gojam and south Gondar (Dera Woreda). The motorized boat carries a crew of two or three members. Their soaking time is about 12 hours.

On Lake Tana, the Ethiopian Orthodox Church development and inter-church aid department (EOC/DICAD) project had introduced five GRP and 25 metal boats with out board and inboard motors all the motorized boats have been provided to fishermen almost free of charge. The technology Allows fisherman to operate on the entire surface of the lake, but producers can not afford its high running cost when compared with economic condition (FAO, 1995). Some repair & maintenance facilities have been provided on Lake Tana by the EOC/DICAD project which has organized a net manufacturing unit with trained women.

There was also project called small scale fishery development project (SSFDP), which was supporting to motorized fishery. The SSFDP, funded by URK, has provided steel vessels with in board engine to fishermen who are working in groups or teams composed of 2-6 persons.

3.6 THE IMPACT OF AGRICULTURAL AND OTHER ACTIVITIES TO POLLUTION OF THE ENVIRONMENT & LOSS OF BIODIVERSITY

Large sediment load through run off, turbidity and accumulation of organic chemicals due to sever erosion of the surrounding farm land by rivers flow in to the lake. the increasing of water demand for different purposes; increasing demand for land, which resulted in deforestation, intensive agriculture with increasing use of fertilizers and pesticides along the shore of the lake. and displacement of lake shore swampy areas and wet lands by agricultural activities are all factors affect the lake condition Wudeneh T(1998).

In addition, different industrial, municipal and domestic wastes added to the lake through run off and dumping from the city, which causes water pollution; all directly or indirectly have effect on water quality and the value of the lake in general, and on the fish ecosystem in particular thus threatening the fishery environment. However, further studies should be done to know the impact of water pollution, soil silt to loss of fish species.

According to survey 20% of the respondents use their agricultural activities near the Lake Tana. This may affect wetland & the reed papyrus, which is favourable for breeding of Tilapia & for some Barbus species. If these activities are not controlled it may lead to loss of fish species.

3.7 MARKET SITUATION IN OF FISH IN LAKE TANA

Between 1997 & 2004 the average subsidized & market prices of major items, such as fuel, & boat have increased to 50% & 30%- respectively. For the same period, the average fish industry price has increased by 20%. The cooperatives sell for FPME & for consumers directly. Therefore, the price is higher to sell to consumers but lower to FPMF. Even though the FPME agreed to buy from cooperatives on contractual base .it looks unfair price if it is compared with that of private fishermen. This is due to lack of refrigerator and other facilities. FPME can be seen a dominant buyer.

The cost of fishing is rising faster than the price of fish because fish is sold only to the FPME. Fisherman out of the cooperative are competing each other for small quantity since FPME is the dominant buyer of the motorized catch it was found to increase fish price in small proportion. Thus, the price paid by FPME to motorized fisherman brought about insufficient returns. Therefore, improving the fish price by promoting competitive market is very necessary. This could be solved by facilitating group credit to fisherman to buy refrigerated cars to provide fish supply to far area like Addis Ababa.

Commercial marketing channels like FPMC and cooperatives do also exit in southern part of the lake. They buy fish only from motor boat catches in large quantities and sale much of the product in processed form than fresh. The FPMC is the only out let that able to sale fish out of local market. The others are distributing fish only to local consumers to satisfy the local demand using the basic market channel (landing point to consumer). This provides reasonable price to consumers and reasonable return to intermediaries due to almost null cost of transportation and other additional costs to reach consumers. (Demissie .S, 2003).

However, it is not the same situation in all corners of the lake. In the northern port of the lake for example, due to limited access to market other than local consumers, and the landing sites and towns are far apart, transportation of quality fresh fish to town market is critical problem. Thus, the price of fish is lower to the whole sellers and to the fish traders unlike the southern part due to increased transaction cost and low quality of fish. While in southern part, the fishers have good access to the potential traders and market due to the near by town Bahir dar and the existence of FPMC, cooperatives and other head load traders. Thus, the transaction cost for traders is low and net return for both traders & fishers is better than the former. (Demissie.S, 2003).

The fishers living far in remote site from markets and road access especially in rainy season in many landing sites around the lake, can not get enough market for the catch and can not supply quality fresh fish to the market. But the fish is dried in an open air and sold even to Metema & Sudan even they sell it greater than the fresh fish price but due to some process to dry the fish, they do not get enough profit.

3.7.1 PROMOTING THE MARKET

In collaboration the fish research center with Tana No 1 cooperative association, the research center and Tana No. 1 cooperative have celebrated a fish day. They have invited people from hotel owners, agricultural Bureau, fishermen & have showed them new fish processing like smoking fish, roasted etc. According to the cooperative chairman, such kind of occasion has contributed to the promotion of fish industry. Therefore due to this effort the price of fish has shown increase in fish price.

3.8 POLICIES AND REGULATION OF LAKE TANA

3.8.1 CURRENT POLICY OF THE REGION

Based on the federal democratic republic of Ethiopia fishers development and utilization proclamation number 315/2003 article 20 article 2;[7] the region has developed its own proclamation number 92/2003 which says the Amhara national regions state fish development, prevention and utilization proclamation. The proclamation states that the region has fisheries potential, which utilized for consumption and economic benefits, it is necessary to devise a suitable controlling system to develop, prevent and utilize this resource suitably and with participation of the public. However, the region still does not have directives& rules in applying the proclamation.

7This proclamation is not, however, implemented as the concerned body does not issue the corresponding directives and procedures.

The proclamation is with the following objectives: 1) Conserve fish biodiversity and environment. 2) Cultivate fisheries resource with appropriate fishing equipment as well as prevent and control over exploitation the fish resource. 3) To make fisheries development to have proper contribution to speed economic growth through the expansion of agriculture development in natural and man made water bodies.4) Increase supply of safe and good quality fish and ensure a sustainable contribution of the fisheries towards food security and create conducive condition that the community found in areas of fisheries resources is to become beneficial and to bring job opportunities.

Regarding the scope of application of the proclamation will be applicable to the water bodies where fish are bred and cultivated and all areas where fishing, preparing and market takes place with in the boundary of the region (proclamation 92/2003 P.P. 4&5).In general the proclamation gives emphasis on environmental protection, handling and processing of fish products, making inspection, protected fishery area and restriction fishing gear. But the proclamation is not changed in to implementation. Therefore, the lake is considered like open access water body.

Even though there is political will, there is lack of effective institutional structure to carry out the task and no enforcement section which helps the department of fish like police & judiciary. This is reflected in their proper handling of catch & effort data of the fish resource and repeatedly stolen of gillnet by the thieves. The MOA did not give attention in recording catch effort on monthly bases because these two inputs are very significant in controlling and supervising & making policy changes. There fore the region is better to give emphasis to put in place appropriate trained staff, & patrolling equipment & allocating enough budgets for the research.

3.8.1.1 RULE & REGULATION OF THE COOPERATIVES

1) A member of cooperatives[8] should be with in the fishing site of the surrounding Lake Tana.
2) Fisherman should not be government employed person.
3) The member should respect the rule & directives of the cooperatives.
4) If the member asks to leave its membership it is possible but its share is given to him after seen by auditors.
5) Owner ship is not transferred from owner to other person

   The office of cooperative association understands the importance of the fish resource i.e by forming cooperatives. It needs to increase the number of the fisherman in order to protect the informal fishermen. The office is searching alternative to give credit for fishermen. However, the office ignores how many fishermen are needed with out affecting the stock of fish.

3.8.1.2 FISHERMAN ASSOCIATION

From the office of cooperative association the number of members in number 1 Tana association is about 150 members of which 16 are women & 134 are men. From 134 men 55 are working with motorboat. On top of that, 14 persons are employed as, chaser, fish seller, storekeeper etc.
The second cooperative is Andnet fisheries association, which is found in Gorgora. Their members are about 255 persons

3.8.2 Administration & institution & services

According to FAO 1995 decentralization process and related administrative restructuring has been done by government of Ethiopia. The regional offices have a total autonomy and their own separate Budgets. In 1993 in the restructuring process, only 7 technical officers were apparently left at FRDD head quarters, while 6 were maintained at Sebeta , the remainder (about 90) being redistributed among the regions.

[8]Cooperatives are found in southern part of the lake named as Lake Tana no 1 and the second is found in northern part named as Andinet.

Channels of communication, coordinating procedures and functional development activities between the central, regional and district set-up are still to be fully devised and materialized. As the researcher interviewed members of MOA, still there is no strong relationship among the federal government & regional government in the sense that they could not get reports of fish catch & effort from the regions. If we consider the resource as the country's resource, therefore without regional data there is no way how to apply a new policy option with out having data from the regions.

There i s a lso l ack o f v ehicles & m otor b oats w hich t hey c an m ake s upervision & c ontrolling. There are a lso c oordination p roblems b etween t he M OA a nd b etween o ther o rganizations l ike police. It lacks coordination between the fishery department with other forestry & agriculture department regarding recording catch & effort. In a place where fishery officer is not available, the agriculture officers should record data by being given training. On the other hand, the fishery department should have cooperation in the time of their observed & illegal fisherman.

4 METHODOLOGY

4.1 CATEGORIES OF INFORMATION REQUIRED

The study was intended to find out the situation of the open-access of the lake, catch & effort, cost of efforts & unit price of fish for both reed boat & motorized fishery. The study is intended to find out the information of catch and effort of 10 years data, p= average fixed price per metric ton of fish catch, c= average cost per unit effort per day, catch by fish species of reed boat and motorized fishery. In addition, information was required on fishery rule and regulation (proclamation), institutional and controlling mechanisms. Moreover, q(catch ability coefficient), k = (carrying capacity of the fish species) & intrinsic growth rate of the fish species.

4.2 SOURCE OF THE DATA

The fisheries data used in this research paper is being collected from the MOA department of fishery, from region 3 agriculture Bureau & from region 3 research center.

The secondary data from 1994-1998 is obtained from region fisheries development project volume No 4&5 & it is on monthly basis by each species. In addition, from 1999-2001 is obtained from region research center. Furthermore, from 2002-2004 is covered by extra polishing. However, for comparison purpose the survey includes data from year 2002-2004 by interviewing the fisherman to get data of catch & effort.

The secondary data includes fish catch, effort and other data are recorded in 8 weredas suchas Alefa takasa (Delgi), Dembia (Debeza), Dembia (Debre sina), Dembia (Achefera), Gondar zuria (Woradiba), Gondar zuria (yidom), Gondar zuria (Armo dinber), Libokakam (Kab), Fogera (christos semera), Dera (korata), Bahir Dar Zuria (FRTC site) B. Dar zuria (woramit), A chefer(Kunzula) of the selected landing places.

Catch is expressed in tons (unless it is stated). effort for reed boat gillnet fishery is defined as number sets of standardized (100m stretched long & mesh size 7 to 12cm). Effort is expressed in fishing days and number of nets.

One fishing day is equivalent to12 hours. Effort for motorized gillnet fishery is also defined the number of sets of 100m (stretched length) net & fishing days i.e expressed in nets days. In addition to the secondary data, the catch & effort are being collected through sampling scheme covering three active weredas. The chase and trap fishery is also not yet covered by sampling programme because its contribution has no significant..

The study is conducted in Lake Tana it consists catch & effort (secondary data), researcher observation and factors for loss of species survey. The study emphasis on fish catch & effort of private traders and cooperative leaders, asking region 3 agriculture bureau fish research center, FPMC & other responsible persons in fishery. It involved collecting information from fisherman how they fish, which instrument they use how much they sell their fish & their costs for fishing & their future perspective in utilization of the resource using questionnaire.

The content of the questionnaires

1) The aim of the questionnaire in appendix V is to interviewing fishers, to collect information on the following type of vessel and gear used, catch & effort, catch per trip, time of fishing, cost per unit effort & price per unit effort.
2) The questionnaire is formulated to identify the open access of the lake; number of fish harvesting, restriction, fishing area restriction, closed season.
3) To know the attitude of fishing as a job by asking the fishermen whether fishing is harder job than the agriculture. Whether the income of fishing is better than agriculture etc.

4) To know the market situation
   Per unit cost of fishing effort
   Per unit price of fishing effort
   To know the profit of the motorized & reed boat

4.3 SAMPLING TECHNIQUES

From 8 weredas surrounding the lake, six sites from 3 corners of the lake of which 2 of them are southern part were purposely chosen because these places are active in fishing activities and assumed that can represent the population. The fisheries are divided in to two that is the motorized & reed boat. This is done because to analyse the two fisheries. The sample as a whole will include only households directly involved in fishing and post harvest activities either as a primary activity or a supplementary source of livelihood.

Based on the data from LFDP from 1993 up to 1997, the increment of fishermen has shown 21%. Therefore, the increment is 5% each year. If 25 persons join to the fishermen then by 2005 the fishermen are expected to be 722. Then if we take 15% of the total fishermen as a sample 108 fishermen are being interviewed.

The respondents were taken randomly as their random occurrences from the landing sites. A total of 108 respondents were taken that is 15% of the total fishermen. This sampling aims to collect, the actual catch, effort, price, cost, the rule & regulations in fishing.

In the study, there are two ways for calculating catch & effort for traditional fishery's & motor boat fisheries.

1) Reed Boat

Total catch = No. of fishermen multiplied by average catch per fishermen per day multiplied by average fishing days per month.

Total effort = total no. of net used per month multiplied by fishing days per month.

Total effort = No. of fishermen multiplied by average net per fishermen multiplied by fishing days.

2) Motorized boat

Total catch = total No. of boats multiplied by catch per boat multiplied by average fishing days per boat

Total No. of net multiplied by catch per net multiplied by average fishing days

4.4 DATA COLLECTION TECHNIQUES

Before the field survey, the researcher has taken a pilot survey and after some adjustments the questionnaire was distributed to the fishermen. Discussion was made with the fishery department authorities which data are available and which data are not available. They advised me to collect good data from 1994/95 - 1998/99 from LFDP and 2000/01 data from region 3 fish research center. Regarding cost of fishing effort of both motorized & Reed boat was taken from the survey.

Fish price was also obtained from fish trading company (FPMC), cooperatives, small scale fish traders, other private traders, and the fishermen at different sites and taken the average price. Both the cost & price of per unit effort are important to calculate the profit of both motorized & Reed boat.

4.5 DATA ANALYSIS

Logistic population growth model is used to describe Lake Tana fishery and the second component of the model is the production function model (Schaefer model). From this model the theory of optimum utilization of the fishery resources and the reason for optimal utilization is developed. The optimal degree of utilization on this fishery is defined in terms of total cost and total production function of the fishery. Total cost and total production are expressed as a function of fishing effort.

MS. Excel was employed to calculate the q= catch ability coefficient, r = growth rate of fish, k= carrying capacity by means of a linear regression of Y/E against E (Conrad and Clark, 1994)).

Moreover, measures of the loss of fish biodiversity will be calculated using the Simpson's index. The Simpson's index is based on the fact that diversity is inversely related to the probability that two individuals picked at belong to the same species as it can be seen in table 7a & 7b

A descriptive analysis was used to study the new fresh entrant of fishermen, to know the dependency ratio, employment level, income level and whether the fisherman use agricultural activities near the Lake or not.

4.5.1 FISHERIES MODEL

According to Gordon empirical work of fisheries is based on the theoretical relationships between species stock level, growth functions, harvest rate, effort and fish catch. The optimal level of utilization on any fishery is defined in terms of total cost and total production, which are expressed as a function of fishing effort. The study seeks to see the property of open access fisheries. Competition among fishermen will then lead to dissipation of rent and to higher level of than the regulated access fishery (Gordon 1954)

The characteristics of fishery is as the level of effort rises, it initially increases output, but later on increase in effort will lead to a fall in the level of output. In such a case there is a maximum sustainable catch which the harvested population can provide. The other character is that the level of effort depends on the nature of property rights in the fishery industry. When fishing is an open access, the bio economic system will be over exploited beyond the Msy level (Bedding ton 1990)

The above-mentioned characteristics can be illustrated using mathematical models. Therefore, logistic population growth model will be used to describe the lake tans fishery.

$F(x_t)= dx/d_t = rx_t\,(1-x_t/k)$---------- logistic growth function------------------------- (1)

Where dx/dt = the change in the fish stock

k= is the carrying capacity

The other model is about production function (Harvesting). Here, catch is related to E (fishing effort) and stock size and is given by

$Y= q \times E$------------ catch per unit (CPE)---(2)

Where y= Fish catch, q is catch ability coefficient

E= level of effort.

When we combine net growth with harvest or production

$dx/d_t = rx(1-y/k) - q \times E$--- (3)

The objective of the lake Tana fishery department is to maintain the stock that gives when there is not change in stock.

$rx(1 - x/k) - qx\,E = 0$ this implies that

$r\,x\,(1 - rk) = qx\,E$ -- (4)

Solving for x gives $x = k(1 - q\,E/r)$, Hence

$Y = qx\,E =$ then , $y = q\,xE\,(1 - \frac{qE}{r})$ -- (5)

Then the equation (5) is the sustainable yield function for Gordon - Schaefer

$$\partial y / \partial E = qk\,(1 - \frac{2qE}{r}) = 0$$

$$1 = 2qE/r$$

$E_{msy} = \frac{r}{2q}$ --(6)

By differentiation the logistic growth function (eqn 1) with respect to x gives

$r = 2xr/k \Rightarrow r - 2xr/k = 0$

$X_{msy} = k/2$--(7)

If we substitute the value of x msy in to equestion 5 we get $ymsy = rk/4$-------(8)

Equations 6, 7,8 are used to estimate the msy after we estimate the unknown parameters like r, k and q.

The optimal harvesting solution will be as follows

$\pi = pqEy - cY = (p - \frac{c}{qx})\,y$-- (9)

The objective is max π

$\text{Max } \pi = \int\infty\,[(p - \frac{c}{qx})\,Y\,)\,e^{\delta t}]\,dt$--- (10)

$\frac{dx}{dt} = rx\,(1 - \frac{x}{k}) - y$ change in biomass constraint

$x_{(0)} = x_0$ Initial condition on fish stock

The current value Hamiltonian is

$$Hc = (p - c/q\,x)y + \mu\,(rx\,(1 - \frac{x}{k}) - y \text{--}(11)$$

Foc steady state, $\mu = x = 0$

$$\pi = (p - \frac{c}{qx}) \text{--}(12)$$

$$\frac{cy}{qx^2} = (d - r\,(1 - \frac{2x}{k})) \text{---}(13)$$

$$rx(1 - \frac{x}{k}) = y \text{---}(14)$$

we get fundamental equation of renewable resources.

$$r(1 - \frac{x}{k}) + \frac{cy/qx^2}{p - c/qx} = \delta \text{---}(15)$$

The internal rate of return = δ

Substitute (14) in to the fundamental equation and solving for optimal stock

$$x^* = \frac{k}{4}\ [(\frac{c}{pkq} - +1 - \frac{\delta}{r}) + * \sqrt{(\frac{c}{pqk} + 1 - \frac{\delta}{r})^2 + \frac{8c\delta}{qpkr}}] \text{------------------------}(16)$$

Optimal value for

$Y^* = r\,x^*\,(1 - x^*/k)$---(17)

$E^* = y^*/\,qx^*$ ---(18)

Solution for an open fishery

Open access => when fishery rent is zero

$$(p - \frac{cx}{q})\,y = 0 \text{ solving x} \text{--}(19)$$

$$x^*_{\infty} = \frac{c}{pq} \text{---}(20)$$

$$y_{\infty} = r\,x_{\infty}\,(1 - \frac{x_{\infty}}{k}) \text{---}(21)$$

$$E_{\infty} = \frac{y}{qx_{\infty}} \text{--}(22)$$

4.5.2 Measures of the loss of fish Biodiversity

The optimal catch is measured in metric tons, given the proportion that the main proximate cause of species biodiversity loss in Lake Tana fisheries is over - Fishing. We should understand the relationship between the level of catch and the species composition of the catch. It is assumed that the abundance & the individual species composition each is related with total harvest. This paper associates the relation ship b/n total harvest & species composition for harvest.

According to kasulo (2000) the idea of species diversity has two distinct concepts. Species richness and evenness: Species richness is the number of species in a community, while evenness explains the abundance of each species in the community. The term that combines the two concepts of richness & evenness is heterogeneity. It is synonymous with diversity and popular because it is relatively easy to measure. One such measure is the Simpson's index of diversity.

The Simpson's index is based on the fact that diversity is inversely related to the probability that two individuals picked up at random belong to the same species. For a population of infinite size, this is given by:

$$D= \sum pi_2 \text{ --- } (23)$$

Where, D is the Simpson index, & pi is the proportion of species i in the community. For a measure of diversity, the complement of Simpson's index is used. It is given as:

$$1\text{-}D = 1\text{-} \sum (pi)_2 \text{ -- } (24)$$

The Shannon index is based on information theory and deals with predicting correctly the species of the next individual collected in a sample.

$$H^*=\sum_{i=1}^{s} (pi)(\log pi) \text{ -- } (25)$$

Inorder to apply these indexes to the case of Lake Tana fisheries, the unit of measurement is changed from number of individuals in a sample population to biomass in the total catch (Goda & Matsuoka, 1988). That is the estimation for a total catch of finite size in a particular period, t, is;

$$D_t = 1 - \sum_{1=1}^{st} [Y_{it}(Y_{it}-1)/Y_t(Y_t-1)] \text{ -- } (26)$$

$$H = 1 - \sum_{1=1}^{st} (Y_{it}/Y_{it})(\log(Y_{it}(Y_t) \text{ -- } (27)$$

In both case, y_{it} is the catch of the species harvested in period t(in metric tone),y_t, is the total catch in period t. the use of these estimates enables us to identify an empirical relation between the diversity indexes and total catch.

4.6 SCOPE OF THE STUDY AND LIMITATION

The study was mainly concentrate on the secondary data. The biological data obtained depends on papers done by FAO , LFDP & MOA papers. Some of the data's were taken by extra polishing but having total catch from 1994-04 from region 3 agriculture Bureau. Lack of sufficient & good quality for four years(2001-04) of organized data .the researcher tried to collect the last 4 years data by interviewing the fishermen that is to know the number of gillnet, catch, effort, kind of gear. However, the information depends on the individual opinion, which may result poor estimation.

From year 2001-04, there was no systematic recording of catch and effort. It is found not aggregated not suitable for analysis. In addition, due to budget constraint the survey is conducted in 3 selected corners(NG,WG,South WG)of the Lake but it would be better if it had covered at least five weradas.

5. EMPRICAL ANALYSIS (MATHEMATICAL ANALYSIS)

5.1 Descriptive analysis (The social dimension of reed boat & motorized fishers)

This chapter tries to assess the importance of Fishing in contribution to food self sufficiency, employment and income distribution. In addition to that it assesses the constraints to improve the food self sufficiency, employment and income.

5.1.1 Food self sufficiency

Still the country and specially the region is facing the problem of food shortage. However, the Lake Tana fisheries are contributing around 1490(1996) ton per year to the community. This implies the lake fishery is important resource. The share of the local harvest is 2.10 kg/head/year for the urban population living around the lake whose total population number is estimated at 556,705 (CSO, 1994). The rate is greater than the national average (i.e 180g) but still less than the towns around rift valley lakes per capita fish 10kg/person/year (Breuil 1993). These days the farmers use more fish during the mosque to breeding time they believe that it might protect from malaria. The fishermen and their parents prefer to eat fish 2 or 3 times as a dish in a week. And people in the town also eat fish than meat because of its significance difference in its price.

5.1.2 Employment

In the past years the fishing activities was considered as the occupation of poor people specially for wayto tribe and undermined by the society. This was one obstacle for the development of fisheries in the past decades. However, this time due to the population growth i.e the son of fisherman becomes fisherman, the degradation of the land fertility and the shortage of food made the fish resource as an important asset that brought food & income.

At present, the fishing is expected to provide direct employment for about 700 fishermen. Each fisherman has got on average of five dependents. In addition, According to the survey in general there are 3545 fishing population which are found to be dependent on the fishery for subsistence. According to Demisei S (2005) there are also people who are working on boat building, processing, net makers & marketing.

5.1.3 <u>Distribution of income and wealth</u>

The survey shows that the income between the motorize and the reed boat are under poverty line (because a person who gets below 1 USD per day in considered under poverty line). Their average per capital income (Birr 2124/head/year) is higher than the industry and higher than the national averages, which are Birr 1800 and Birr 3,800/head/year (Silesh 1998) respectively this does not show the reality because (20%) the also fisherman depend on agriculture.

In addition, the distribution of the income differs among the fisherman group. The net maker are lowest income earners, with Birr 100/month as compared to other who work with in the cooperatives. In the cooperative, there are 14 women who work as net maker.

With in the fisherman themselves monthly average gross income varies from birr 125 to Birr 230 per Reed boat fisherman and per motorized fisherman respectively. Because one person works for a week only. It will be very important if women participate in income generating with their family fisherman so as to increase their income. The fisherman is the head of the household decides in allocation of their income. It is observed that a significant part of their incomes spend on entertainment i.e drinks .Moreover, significant part of their income spend during the marriage & other occasions, therefore, their saving capacity is very low.

5.1.4 <u>Dependency on fishing activities</u>

Table 1a fishing experience in Lake Tana

Experience	Frequency	Percentage
Below 5 years	30	28
5 to 15 years	58	53
Above 15 years	20	19
Total	108	100

Source: own survey

As it is shown from table 3, among the respondents 72% of fishermen have worked more than 5 years and 28% of the fishermen are new entrants. This shows that 72% of fisherman are depend their life on fishing. On the other hand 28% are new comers to fishing activities because they do not have alternative job some where and some of them are school leavers.

5.1.5 Agricultural activities near Lake Tana

Table 1b agricultural activities near Lake Tana

Activities	Distance from the Lake	Frequency	Percentage
Agriculture	20-50 meters	22	20
"	100-500 meters	35	33
"	Above 500 meters	51	47
Total		108	100

Source own survey

From survey taken in Lake Tana, 20% of the fishers do their agricultural activities near Lake Tana that is from 20 meter to 50 meter and 80% of the fishermen do their agricultural activities far from the Lake above 100 meter. Therefore, this shows that the 20% of the fishermen are affecting the wetland or distracting the habitat of fish like cutting down the reed plant for reed boat making.

5.2 TO ESTIMATE A,B,R & K, AND TO GET OPEN ACCESS, OPTIMUM & MSY SOLUTION FOR BOTH MOTORIZED & REED BOAT

The Gordon -Schaefer model uses the known values of catches (y) and effort (E), and the unknown parameters q (catchability coefficient) and r (growth rate of fish species). Data on catch and effort is used to get estimates of the parameters r& q as follows. The sustainable yield function for Schaefer model (equation 5) will be written in the following form:

$Y/E = qk - q2k\ E/r = a - bE$

Where a = qk and b = q2 k/r. The coefficients a & b can be estimated by means of a linear regression of Y/E against E (Conard and Clark, 1994) .

Assuming u =Y/E, we set

$du/dt = qu\ (a/b - E^* - u/b)$

The integral of the above equation after rearranging terms is

$$\frac{du}{u(a/b - E^* - u/b)} = qdt$$

$qt^* = \ln [/Zu^{-1}_t - 1/b)/(Zu^{-1}_t - 1/b/]/Z$--(28)

where Z = a/b - E* and E* = $(E_t + E_{t+1})/2$, the effective effort between year t & t+1 Equation (23) is used to estimate the sequential values of q* which are supposed to be positive. With time series for q,*an integral assessment can be obtained by taking the arithmetic mean or geometric mean (Fox, 1975, conrad and Adu- Asamoah, 1986). Given the values of a , b and q*, estimates are made for k and r as follows.

k* = a/q -- (29)

r* = q2 k/b---(30)

q,r and k is used to estimate the optimal stock x*, using equation (16) by choosing appropriate values for cost of effort(c), average price of fish , p, & discount rate δ.

TABLE 1c DATA CATCH & EFFORT OF LAKE TANA. (REED BOAT)

Year / month	Catch (ton)	EFFORT net days	CPUE
1987	521,8	280,667	0.002
1988	863,4	345,584	0.002
1989	1,109,0	443,290	0.003
1990	945	378,125	0.002
1991	645	278,501	0.002
1992	602	228,548	0.003
1993	772.4	267,333	0.003
1994	1,156.3	426,996	0.003
1995	663	253,804	0.003
1996	755.6	294,590	0.003

Source: LFDP (1993) & stat. bull. No 4 & 5 and own survey

TABLE 1d DATA CATCH & EFFORT OF LAKE TANA. (MOTORIZED)

year	Catch (tons)	Effort net days	CPUE
1987	347.90	2469	0.01409072
1988	279.95	2140	0.1308178
1989	360.02	2752	0.130814
1990	307.01	2347	0.1308053
1991	250.1	1726	0.1308227
1992	202	1416	0.130791
1993	252.2	1657	0.1307785
1994	356.4	2646	0.1307634
1995	230.71	1583	0.1307644
1996	236.57	1831	0.13052977

Source: LFDP (1993) & stat. bull. No 4 & 5 and own survey

But in estimation the model monthly data was used.

Considering the above tables, we can estimate Y/E against E then the regression is as follows.

Appendix I Table 1e

REGRESSION RESULT FOR REED BOAT SURVEY

Dependent Variable: U1

Method: Least Squares
Date: 05/22/05 Time: 07:33
Sample: 1987M01 1996M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004785	0.000258	18.53421	0.0000
E	-7.28E-08	9.96E-09	-7.307298	0.0000

R-squared	0.311538	Mean dependent var	0.003023
Adjusted R-squared	0.305704	S.D. dependent var	0.001214
S.E. of regression	0.001011	Akaike info criterion	-10.93873
Sum squared resid	0.000121	Schwarz criterion	-10.89227
Log likelihood	658.3239	F-statistic	53.39660
Durbin-Watson stat	1.108259	Prob(F-statistic)	0.000000

Source: Own competition

Table 1f

REGRESSION FOR MOTORIZED BOATS SURVEY

Dependent Variable: U1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019418	0.001894	10.25414	0.0000
E	-3.18E-06	4.87E-07	-6.518009	0.0000
R-squared	0.266386	Mean dependent var		0.007633
Adjusted R-squared	0.260116	S.D. dependent var		0.007139
S.E. of regression	0.006141	Akaike info criterion		-7.330954
Sum squared resid	0.004412	Schwarz criterion		-7.284246
Log likelihood	438.1918	F-statistic		42.48444
Durbin-Watson stat	1.856745	Prob(F-statistic)		0.000000

Source: Own competition

As the result is shown in table 1c & 1d catch per unit effort (CPUE) is dependent variable & effort (E) is independent variable. there is negative relationship between the two variables because as effort increases the CPUE decreases. Therefore, the result shows that the coefficient of E is statistically significantly affect CPUE. Since D.W is greater than R2 there is no spurious regression time series. According DF & ADF test the time series for motor boat is stationary because the τ(tua) is greater than critical values for both fisheries see table 1c&1d..

The main purpose of the regression is to estimate the value of a & b and to see the relaship between CPUE & effort not regression.

Table 2 Estimates of a,b,q,s&k for motorized & Reed boat gillnets

Fishery	**a**	**b**	**q**	**r**	**k(m. ton)**
Motorized	0.019418	0.00000318	0.00024	1.449	80
Reed boat	0.004785	7.28E-08	0.000018	1.182	265.8

Source: Own competition

Table 3a <u>Optimal, msy & open access solutions for the reed boat</u>

Optimal	**MSY**	**Open access**	**Actual average**
Y* = 37.03	YMSY = 78.54	Y∞= 61.85	Y = 63
E* = 8963	Emsy = 32,833	E∞ = 17,782	E = 18,008
X* = 229.52	Xmsy = 132.9	X∞ = 193.24	

Source: Own competition

P= 3450; C=12 δ= 0

Where p is price of fish per ton, c is cost of unit effort per Day, δ is discount rate.

Table 3b <u>Optimal, msy & open-access solutions for motorized boat</u>

Optimal	MSY	Open-access	Actual average
Y* = 12	Y_{MSY} = 28.98	Y∞= 20.77	Y = 22
E* = 706	E_{MSY} = 30189	E∞ = 1413	E = 2244
X* = 70.8	XMSY = 40	X∞ = 61.27	

Source: Own competition

P= 3400, c= 50, δ=0

For motorized boat fishery, the results show that the average catches (22t) were below the Msy level (28.98). This is probably because of the increasing the steel boat price and the running cost like fuel, oil and gillnet see table 12 & 15. Except in years 1987, 1988,1989,1990,1994 E.C the average c atches p er m onth w ere 2 8.9,23.4,30,25 & 2 9.6 r espectively c atches a re b eyond M sy. The reason for exceeding actual catches beyond Msy is because during rainy season from June - August specially the barbus comes out from the lake to the river mouth for breeding and the fishermen fish easly.. On the other hand, as it can be seen from table 3.b, the actual average (22 ton) is very close to the open-access harvest that is 20.77 and not to the optimal solution, therefore, this shows that the model we have used fits the open-access.

For reed boat fishery, the actual average catch (63) were below the msy harvest level (78.54). As Kasulo(2000) mentioned in the Malawi fishery, the reason for actual catch below the Msy is due to high cost of unit effort. This is true to the Lake Tana why the actual average is below Msy the reason for this is due to increase in the unit cost like reed boat, gillnet & floater in the market. Fish catches were above Msy only in 1989 E.C & 1994 E.C when the average monthly catch were 92 & 96.36 (ton) respectively. The highest harvest is shown in December, February, March & June. This shows that the harvest in December, February & March are high because of high demand during the fasting period. However, during June the barbus fish comes out from the Lake to river mouth for breeding and the reed boat fishers fish barbus during this period. This is because of poor economic power of the reed boat fisher. According to the survey, 18% of the respondent said that we do not stop fishing during the breeding time. Therefore, this shows that a great attention should be given when we close breeding season.

In general, when we see the results in table 3.a d & 3.b the optimum solution of effort & catch (8963 & 37.03) are lower than Msy & open access solution of effort & catch 32,833, 78.54 & 17,782 & 61.85 respectively. This shows that optimum solution is better for biodiversity than the Msy & open-access. Because the optimum solution has higher fish stock than the Msy & open access solution fish stock.

In addition, the financial implication of profit of Msy & optimum solutions is as follows: profit is calculated by subtracting the cost in fishing from the revenue that is п=(P-C/qx) Y. As it is shown in appendex v 7 & 8. For motorized boat fisheries, the optimal solution leads a profit of 5489.27 birr while Msy solution leads to loss of 52,405 birr. For reed boat fishery, the optimal solution leads to profit of 20,188 birr where as the Msy solution leads to loss of 23,025.44 birr. By assumption, the open-access solution leads to zero profit for both the motorized & reed boat fisheries. Because the optimum solution uses less effort & catch than the Msy solution. This leads to profit of 5489.29 birr (motorized boat) because the stock of fish is higher and this brought less per unit effort cost because when the fish stock is higher, the fisherman catches easly with minimum c ost. O n t he other h and, t he M sy s olution i nvolved h igh e ffort & c atch (30,189 & 28.98). This shows that l ess fish stock means high unit effort cost because when fish stock is lower therefore the fisherman makes higher effort or trip to get the same kind of kg or ton.

As we can see from the result the motorized boat optimal solution leads to 5489.27 birr & optimal solution of reed boat leads to profit 20,188 birr. If we divide the profit to number of fishermen, considering 90 fishermen & 618 for motorized reed boat the profit is 61 birr per person including the opportunity cost of income & 32 birr per person per month. This is may be due to the capacity the motor boats have to fish inshore & off shore. However, the reed boats have limited capacity to go to offshore. Therefore reed boat catch 15kg per day that is less than motorized boat (46 kg per day per fisherman). Even thought, the profit seems low but they don't depend on fishing only.

Table 4a Survey& LFDP motorized boat catch by each species Lake Tana

Year	Total catch in ton	Barbus	Cat fish	Tilapia	Beso
1987	347.90	59.6	131	155.60	0.77
1988	279.95	49.96	105.68	125.53	0.64
1989	360.02	64.34	135.91	161.43	0.83
1990	307.01	92.10	98.24	110.52	6.14
1991	250.10	80.03	75.03	90.04	5.00
1992	202.0	64.64	60.60	72.72	4.04
1993	252.2	80.7	75.66	90.80	5.04
1994	356.4	114.05	106.92	128.30	7.13
1995	230.71	47.77	61.40	121.54	0.0
1996	236.57	57.91	59.23	119.43	0.0
1997	294.24	65.10	62.91	166.23	0.0

Source: LFDP and own survey.

Table 4b survey LFDP motorized boat catch by each species of Lake Tana

Year	Total catch in ton	Barbus D	Cat fish	Tilapia	Beso	Total D	Average catch per month (ton)
1987	347.90	0.028939	0.141109	0.1993243	0.00000132	0.63062908	28.9
1988	279.95	0.0313225	0.1416608	0.0200158	0.00000295	0.807003	23.4
1989	360.02	0.03152929	0.1410051	0.02003662	0.0000010	0.8074299	30
1990	307.01	0.089281	0.101652358	0.128800771	0.00035827	0.6799300	25
1991	250.10	0.10152136	0.0891569	0.12868	0.00033	0.680311	20.8
1992	202.0	0.101318	0.088956	0.128454	0.00050	0.680772	16.8
1993	252.2	0.101676	0.089165	0.128706	0.00033	0.680123	20.8
1994	356.4	0.101792	0.08941	0.128944	0.000345	0.679509	29.6
1995	230.71	0.042158	0.069977	0.27642	0.0	0.611445	19.2
1996	236.57	0.059137	0.061189	0.253802	0.0	0.625872	19.7

Source: LFDP and own survey.

Table 5a Survey & LFDP Reed boat catch by species revised

Year/ month	Total catch in ton	Barbus	Cat fish	Tilapia	Beso	Average catch per month (ton)
1987	521.80	247.30	128.60	136.20	9.70	43
1988	864	292.70	248.50	307.80	15.00	72
1989	1110	377.40	321.9	388.50	22.2	92.5
1990	945	320.3	272.2	336.4	16.1	78.75
1991	645	226.30	183.18	224.46	10.96	56
1992	602	211.30	170.97	209.50	10.23	50.2
1993	772.4	271.11	219.36	268.80	13.13	64
1994	1,156.3	369.92	346.89	416.27	23.13	96.4
1995	663.50	212.32	199.05	238.86	13.27	55.3
1996	755.60	266.68	241.79	272.02	15.11	62

Source: LFDP and own survey.

Table 5.b Survey and LFDP Reed boat catch by species in Lake Tana

Year	Total Barbus	Barbus	Cat fish	Tilapia	Beso	Total (D)
1987	521.80	0.2241369	0.06038326	0.0677608	0.00031053	0.6474085
1988	864	0.11450767	0.08248539	0.1266483	0.00028164	0.676077
1989	1110	0.11539765	0.8391433	0.1222948	0.00038232	0.678010
1990	945	0.11453697	0.08275114	0.1264780	0.0002725	0.675961
1991	645	0.12285271	0.08034024	0.12075167	0.00026279	0.67579259
1992	602	0.12281963	0.08031954	0.1207310	0.000260979	0.675838851
1993	772.4	0.12290351	0.08039122	0.1208141	0.0002710	0.6756201
1994	1,156.3	0.10215854	0.08481822	0.124018	0.0000173	0.678604
1995	663.50	0.10207154	0.089683	0.1292522	0.0003704	0.6786228
1996	755.60	0.089721	0.102109942	0.12929848	0.0003739	0.678499

Source: LFDP and own survey.

Reed boat Simpson regression result

D= 0.662491 - 1.31E-05 y
(0.010807) (1.25E-05)

Motorized Simpson regression result

D= 0.572637 - 0.000376 y
(0.120319) (0.000418)

Table 6 simpson index result from motorized reed boat

		Motorized			Reed boat			
Index	Average	Optimal	Msy	Open access	Actual average	Optimal	Msy	Open access
D	0.5639	0.5681	0.5617	0.5648	0.6616	0.6620	0.6615	0.6616

Source: own competition

As results show that an increase in fish catch would lead to loss of fish biodiversity. The biodiversity indexes for actual, optimal, msy & open-access can be seen from the index functions. The results are shown in table 6 in the above table. The optimal for motorized (0.5681) level of biodiversity is higher than the actual (0.5639) for simpson index and the optimal for reed boat level (0.6620) is higher than the actual (0.6616) for simpson index. Because as it is shown in table 5 & 6 the optimal harvest for example & reed boat actual harvest is 63 ton & simpson index is lower 0.6616 (the higher value of index the greater the diversity). Even though, there is a small differences between the actual & the open access in biodiversity indexes, they have the same biodiversity index this reflects the assumption of free entry or open-access.

Therefore, optimal solution is better to use to reduce loss of biodiversity. As the result shows that the msy is not the best solution for the conservation sustainable utilization of biodiversity.
This is because the optimum harvest & effort is lower than the actual harvest. This means the more the harvest the lower the biodiversity. Furthermore, as the result has shown the harvests are more than the optimum which is without getting profit the reason for this may be the fishermen do not have an alternative job. Therefore, this may lead to extinction and those who depend their livelihood on fish resource may be unemployed & then they loss their income this expands to suffer the food insecurity in the region.

5.3 Sensitivity analysis of open-access & optimal solution.

Sensitivity analysis of the optimal & open-access solutions to changes in the discount rate, cost of effort & price can be demonstrated their effectiveness in tables 7a & 7b. This can be done by changing each variable while holding the other two constant.

Table 7a sensitivity analysis of the optimal and open-access solutions to changes in δ ,c and p for motorized boat

	Optimal			**Open-access**		
Variable	X*	Y*	E*	X∞	Y∞	E∞
δ						
0.00	70.60	12	710	61.27	20.77	1413
0.05	70.45	12.19	721	61.27	20.77	1413
0.10	70.28	12.37	736	61.27	20.77	1413
0.15	70.11	12.55	747	61.27	20.77	1413
C						
10	46.13	28.26	2553	12.25	15	5102
10	52.25	26.23	2092	24.51	24.6	4181.90
30	58.3	22.88	1635	36.76	28.75	3258
50	70.8	12	706	61.27	20.77	1413
P						
3400	70.8	12	706	61.27	20.77	1413
3450	70.2	12.44	739	60.39	20.77	1478
3500	69.8	12.88	769	59.52	22.05	1544
3600	68.9	13.83	836	57.87	23.16	1668

Source: own competition

TABLE 7b **Sensitivity analysis of the optimal & open-access solutions to change in , c , δ & p, for reed boat fishery**

Variable	Optimal			Open-access		
	X*	Y*	E*	X∞	Y∞	E∞
δ						
0.00	229.50	37	8956.60	193	61.9	17,818
0.05	228.58	37.83	9195	193	61.9	17,818
0.10	227.81	38.49	9387	193	61.9	17,818
0.15	227	39.17	9586	193	61.9	17,818
C						
7	188.70	64.71	19,051	113	76.6	37,659
9	204.75	55.60	15,086	145	77.6	29,732
11	219.95	44.85	11328	177	69.5	21,814
12	229.23	37.21	9016	193	61.9	17,818
P						
3450	229.23	37.21	9016	193	61.9	17,818
3500	227.9	38.41	9363	190	63.5	18,567
3550	226.6	39.5	9686	188	64.5	19,060
3600	225.3	40.6	10,011	185	66.0	20,000

Source: own competition

For the two fisheries, higher discount rates imply lower optimum values for the stock variable and higher optimum values for both catch and effort. Open access levels remain constant because dissipation of economic rent in the open-access is equivalent to setting an infinite rate of discount, which gives zero value on future profits.

For reed boat fishery when the discount rate is zero the optimum stock, harvest & effort are 229.50 37 & 8956.60. On the other hand when discount rate is 0.15 the stock & harvest & effort become 227.39 17 & 9586 respectively. This shows that when the discount rate increase from zero to 0.15 the stock has decreased from 229 to 227 & catch & harvest increased from 37 & 8956.60 to 39,17 & 9586 respectively. This is due to an investor sees future net present value less therefore an investor harvest more to day than tomorrow. However, when the discount rate from 0 to 0.15 the open-access stock & harvest & effort remain constant

For motorized boat fishery, when the discount rate increases from zero to 0.15. The stock has decreased from 70.60 to 70.11 and catch & effort have increased from 12 & 710 to 12.55 & 747 respectively.

Open-access level remains constant for both fisheries because dissipation of economic rent in the open access is equivalent to setting an infinite rate of discount, which gives zero value on future profits.

It can be concluded that under optimum conditions, increase in discount rate will lead to loss of fish biodiversity through an increase in catch & effort and a decline in stock.. A rise in the cost of effort increases the optimal level of fish stock and decreases the optimal level of fish catch & effort. This agrees with the theory, this implies rising costs lead to high levels of biodiversity since they reduce harvest levels & raise optimal stocks.

On the other hand, a rise in fish prices leads to a reduction in optimal stock level and an increase in fish catch & effort for motorized & reed boat. For an open-access fishery, a price increase (other factors remaining constant) would invite more fishermen to enter and exploit the fishery up to the level of rents associated with the price increase are dissipated. this may be expected to result in the loss of dissipated. This may be expected to result in the loss of biodiversity due to the reduction in fish stock.

The equilibrium level of catch is determined by both biological & economic parameters. Given the biological parameters (r,q & k), catch becomes a function of the cost-price ratio. If fishing costs are sufficiently high relative to the price of fish, the fishery will not be exploited. However, when the cost is low (higher price), the fishery would become profitable and an open access level can be established at the point where economic rent is zero. Economic incentives can be used to vary the economic parameters and reduce loss of biodiversity. For example, a tax can be imposed on fish catch to reduce the price and improve the level of biodiversity.

According to Conrad & clark (1994) in competitive resource exploiters attempt to maximize their own rent revenues over the short term forgetting the long-term effects that their harvest will have effect on the resource stock. The competitive fisherman behaves as if the user cost of the fishery (the shadow price in equation(11) of the model is zero.

Therefore, tax can be used to reverse the stock externality . A fisheries management agency should force fishermen to recognize the user cost. The price received by the fisherman will b e r educed b y t he a mount o f t he t ax. T his may f orce t o e xercise a t t he optimal level of effort. It can be concluded that a tax on harvest that is equal to the shadow price or user cost will force fishermen to reduce their effort to the levels & improve the level of biodiversity in the inshore.

On top of that, the discount rate has an effect on fish catch & loss of biodiversity. The higher the discount rate the lower the present value of a given payment in the future. The income earned can be considered as "opportunity-cost income" because the cost of effort includes the opportunity cost.

5.4 Major problems & constraints

Open-access of the fisheries

According to Sileshi, Tilapia is fully utilized /Barbus started to be over fished. Despite this the fisheries are open to every interested person who wants to engage in it such they are rather encouraged and supported to do so under such circumstances. Due to its open access in the inshore lake the catch per unit effort is declining from time to time.

Constraints of inputs supply

It is clear that the introduction of motorboats by NGO's has increased the production but it is far from the potential. Since 70% of the fisheries are traditional, some of the traditional fisheries use forbidden fishing technique like using poison. This may be due to shortage of imput & their expensiveness in the market. On the other hand non-recommended fishing practice in the river and river mouth which interrupts their normal reproductive cycle like barbus species migrating to river mouth during kiremit.

Shortage of credit facility

In Lake Tana the most important constraint is financial shortage because to increase expand the fish production, the fishermen needs, improved vessels & gears. Therefore, with limited harvesting capacity with low level of price, this leads to low saving. It is unlikely to invest an improved vessels. In the past decades the external financing development of the Tana fishery had a positive relationship.

Market limitation

The cooperatives do not have the power to negotiate with FPME (corporation). The cooperatives sell their harvest on contractual agreement with FPMF (corporation) auction could be one way possible method for increasing the fish price. The local government should encourage and provide necessary technical support to facilitate competitiveness in the study.

6 Conclusion & recommendation

6.1 Conclusion

1) For both motorized & reed boat fisheries the actual catch were below Msy because of increasing cost of unit of effort. Where as the actual out put is beyond Msy because of institutional problem or no effective regulation (open-access) & increasing demand during fasting period.

   The actual harvest is beyond the optimum because its economic situation of the fisherman in the region (no alternative job & less productivity in agriculture) and low purchasing power to buy motor boat. On the other hand, the shortage of input like net, floater & lead & theft of the nets made the fishermen to fish migratory fish of barbus.

2) About 20% of the fishermen are involving in agricultural activities near the lake. These activities are destructing the comfortable place of tilapia this may also contribute loss of fish species.

3) From the previous discussion, 80% of fishermen have above 10 years experience of fishing. Where as the 20% of the fishermen are new entrants. This shows that still the lake is threatened by increasing effort.

4) The loss of biodiversity is higher in motor boats than reed boat because of the intensity of fishing or the capacity in fishing in inshore and offshore. However, some traditional fishermen use below the standard mesh size.

5) The actual Simpson index is lower than the optimum. therefore, higher optimum Simpson index means higher the biodiversity.

6) As the result shows the profit of optimum solution is higher than the maximum sustainable solution profit.

7) The cooperatives do not have power to negotiate with FPME. The cooperatives sell their products on contractual agreement. The local government should encourage & provide necessary technical support to facilitate competitiveness.

If we compare the Malawi result with that of Lake Tana, Both are open-access Lakes but Malawi's lake uses like gear restriction, close season & licence. In both cases the catch results are below the Msy except few years. The reason for this was increasing per unit cost of effort. There was no coordination between fishery department and other institutions (police) in both Malawi & Lake Tana. In Malawi the loss of fish species is due to excessive harvest where as, in Lake Tana it is excessive harvesting (use of poisoned plant) & migratory nature of the barbus fish during it breeding time.

The policies in Lake Tana are designed to protect against the decline in stocks below the Msy level. They are driven by a management goal maximizing sustainable yield not economic one.

Therefore, it is better to identify strategies that could make the fisheries operate at optimal level to reduce loss of biodiversity. According Kasulo (2000) in recent years applying economic instruments to biodiversity problems has gained wider acceptance. Therefore in addition to the mentioned command and control tools, economic incentives c an be used. These incentives are changes in price of fish, discount rate and cost of effort. As the study indicates, the actual harvest is greater than the optimum. Therefore tax should be imposed to each tone harvested. And for those who go out of fishing activities credit should be given to work on other activities .but this should be discussed with fishermen community.

In general, the causes for fish depletions in the inshore are:

Open-access, no entitlement of ownership, habitat destruction interruption of migratory of barbus fish, using poisoned plant, no gear restriction, no job alternative & low income from agricultural product.

6.2 Recommendation

There are two options for managing the Lake Tana

Option 1)

To move the fishing activities to the offshore. This can be done by organizing the fishermen to form cooperative and select among the fishermen who should be the member of the cooperatives by formulating some criteria (issuing license to the fisherman). Moreover, the cooperative association organization department should facilitate credit to fishermen to buy motorized boat.

Option 2)

1. If the first option could not be applied then the responsible body should limit the number of fishermen, by giving licensing to the fishermen.
2. Credit could be arranged to fishermen to start small scale business like weaving, wood and metal works and agricultural activities like cash crops eg. Coffee, Chat & Mango.

In doing the above options, the proclamation should be implemented by providing rules & directive. Even thought expertise should be put in place to record all necessary data of fish. Supervising and coordination with other institution like police is important.

The fishing department should ban to those who make agricultural activities near the lake because the fisherman are destroying the habitat of the fish. In addition to, the new entrants should be registered by the department of fish and get license. Otherwise with out permission no one should join to the lake fishery.

6.2.1 Command & control tools

1. **Gear restriction** - protecting destructive gear (eg. Poisoned plants). The farmers should get education not to use the poisoned plant.
2. **Mesh s ize r egulations** - there are some reed boats that use local gillnets which is below standard mesh size. This kills the fish before they reach the age of reproduction. This kind of gillnet should be restricted but the cooperatives should provide to substitute the gear.
3. **Closed areas/seasons** - both the reed & motor boat fisheries have been fishing out the spawning species in rivers & river mouths at particular season which may brings fish depletion. Therefore, to close these are as is important. But this should be done by convincing & telling the consequence of the practice to the community.
4. **Control of fishing effort** - controlling the effort can be done by giving fishing license to decide mesh size, number of standard nets, & number of boats.
5. **Participating the community** - this is done by sharing the responsibility between the government & local community because this satisfies both the government and local.

6.2.2 Economic incentives

Credit facilities - credit should be given to the fishermen to expand the off shore & increase their income & employment & improve food self sufficient.

Credit should also be given to those who are fishing in the inshore to reduce effort by forcing the farmer to go out of fishing & to participate in other activities. As it is mentioned in option 2.2.

Tax - tax should be levied to the in shore fishers to realize the user cost. Because if it is open-access fishermen do not care about the fish resource.

There must be punishment of heavy tax and fines for those who fish small aged fish & use poisoned plant. On the other hand, Tax incentive should be given to those who work in offshore(tax free) .

Therefore, as the region is suffering from food s elf sufficient the most p romising prospect for meeting food sufficient is to expand fishing on offshore and to reduce over-exploitation of the inshore.

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Table 8 Fishing producer prices (Birr/kg/ Lake Tana

	1987 E.C	1988	1989	1990	1991	1992	1993	1994	1995
FPME									
Tilapia whole	0.75	0.90		0.90					2.38
Tilapia filleted									11.00
Tilapia gutted									2.25
Barbus whole	0.65	0.75							1.90
Barbus gutted									4.80
Catfish whole	0.40	0.55		0.55					2.00
Cat fish Fillet									2.38
Cat fish gutted									5.00
Local trader									
Tilapia whole	1	1.25		1.30	1.30	1.40	1.40	-	1.50
Tilapia fillet									
Cat fish whole		0.75							.80
Barbus whole		1.25							1.30
Carp whole									
Nile perch gutted									
Nile perch fillet									
Begrus gutted									
Quanta (dried labeo)	0.60								
Labeo gutted									

Source: LFDP (1998) & own competition

Table 9 Retail prices of fish birr/kg

	A.A	Bahir Dar	Gondar	Gorgora	Hamusit	Humera	Haik
Nile perch fillet	18.28						
Tiliapia whole	3.90-5.00	1.59-200	2.50	0.75-1.00	1.50		1.25
Tilapia gutted	4.20-6.80		3.50				
Tilapia gutted smoked							
Tilapia fillet	9.00-15.00	4.20-4.30	9.00				
Tilapia filleted smoked							
Barbus whole		1.39-1.75	2.25	0.75-1.00	1.00		
Barbus gutted	5.90 5.20-	1.25	3.00				
Barbus fillet	5.90	3.69	4.94-5.00				
Cat fish whole	6.00			0.50			1.00
Cat fish fillet	7.50		4.20				
Carp fillet	5.90						
Bagus gutted Dried fish						13-20	

Sources: LFDP (1998)

Table 10 changes in fishing vessels, gears & fishermen b/n 1993 -1997 by fishing zones

Fishing zone/inputs	WG			SG			NG			Total			
	1993	1995	1997	1993	1995	1997	1993	1995	1997	1993	1995	1996 or 1997	% change b/n & 1997
Fishermen	129	259	259	91	70	70	181	185	185	401	514	514	28
Motorised boat	17	20	20	5	6	6	1	0	3	23	26	29	26
Steel	13	16	16	4	5	5	0	0	1	17	21	22	29
Fibre glass & wooden	4	4	4	1	1	1	1	0	2	6	5	7	17
Reed raft	65	87	164	2	6	6	73	102	108	140	195	278	99
Gill net	755	1228	1266	66	89	89	348	429	437	1169	1746	1792	53
Modern (10-120 mm)		312	350		79	79		227	235		618	664	7
Local (70-90 mm mesh)		916	916		10	10		202	202		1128	1128	0
Average (%)													37

Sources: LFDP (1993) and stat. bull. No. 4 &5

Motorized boat summary 1997 E.C
Average price sell to consumers

Table 11

Type of fish	Price
Tilapia (whole) ……..	3.20
Barbus (whole) …….	2.00
Catfish (whole) ……	5.00

Average price = $3.4 per kg

Source: own competition

Cost of effort

Table 12

Cost of effort	Per year
- Modern gillnet at birr 717 average price/3 yrs life time	239
- Wage 2 person 6 birr/day for 216 dys/yrs -----------------	3024
- Mentenance of boat/yrs ---------------------------------------	703
- Mentenance of gillnet/yr --------------------------------------	49.2
- Fuel expense per year ---	5880.80
- oil ---	504.00
- Average rent for boat per month ----------------------------	400.00
- Per unit cost of effort per year -------------------------------	10,800.00
- Per unit cost of effort per month 10,800/12 months -----	900.00
- Per unit cost of effort per day 900/18dys -----------------	50.00

Source: own competition

Reed boat summary 1997 E.C

Price of fish sold to consumers

Table 13

Type of fish	Price
Average Tilapia whole ------------------	1.15
Barbus ------------------------------------	1.15
Cat fish ----------------------------------	1.00
Total --------------------------------------	3.30

Source: own compition

Average price is 3.30/3 = 1.10

Table 14

Type of fish	Price
Tilapia kanta	4.5
Barbus kanta	4.90
Catfish kanta	8.10
Total	17.50

Source: own compition

Average price for 3 species 17.50/3 = 5.8

Average price of whole & kanta = 1.10 + 5.80 = 6.90/2 = 3.45 per kg

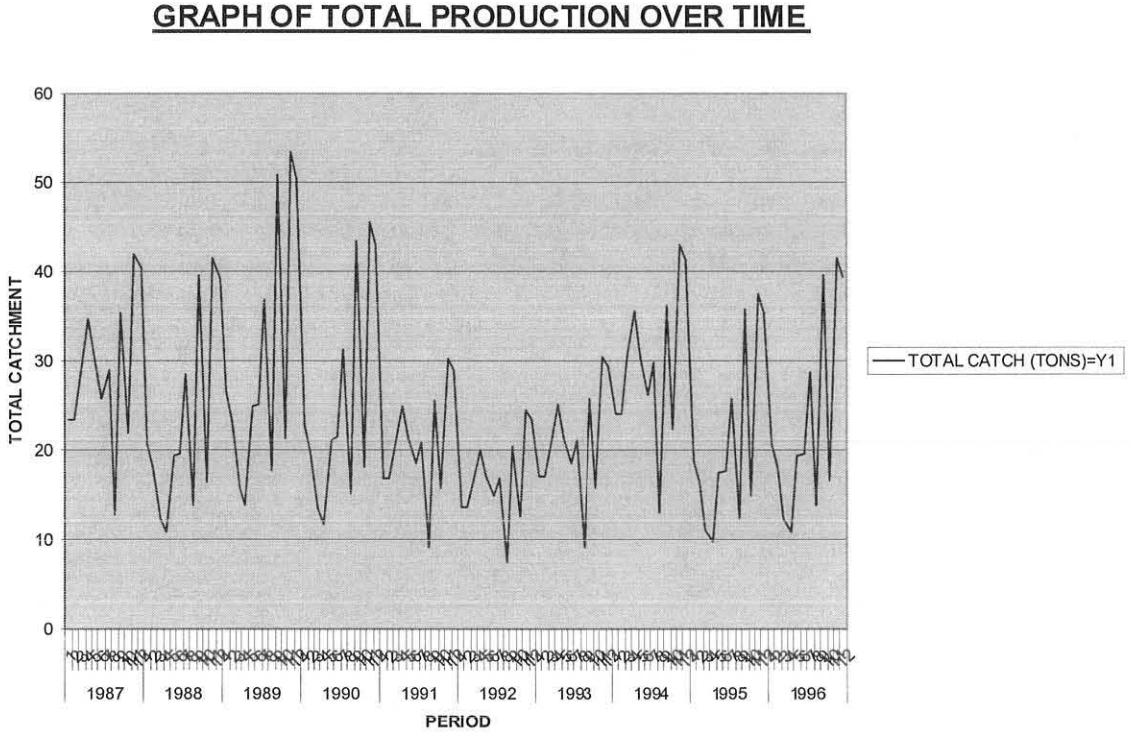
Reed boat per unit effort cost (per net)

Table 15

Cost of effort	Per year
Reed boat for unity 51.2 birr 2 months life time ----- 51.2x6 --------------------	307.20
Modern gillnet 100m birr 800 birr for 3 yrs life time ------------------------------	266.00
Wage birr 7/head/day 288 dys/yr ---	2016.00
Maintenance for a net per year --	70.00
For helpers on average women per fishermen 1x2 4 dys x 3.09 birr x 12 -----	889.92
Total expenses per year --	3549.12
Total expenses per month ---	295.76
Total expenses per day (295.76/24 days) --	12.32

Source: own competition

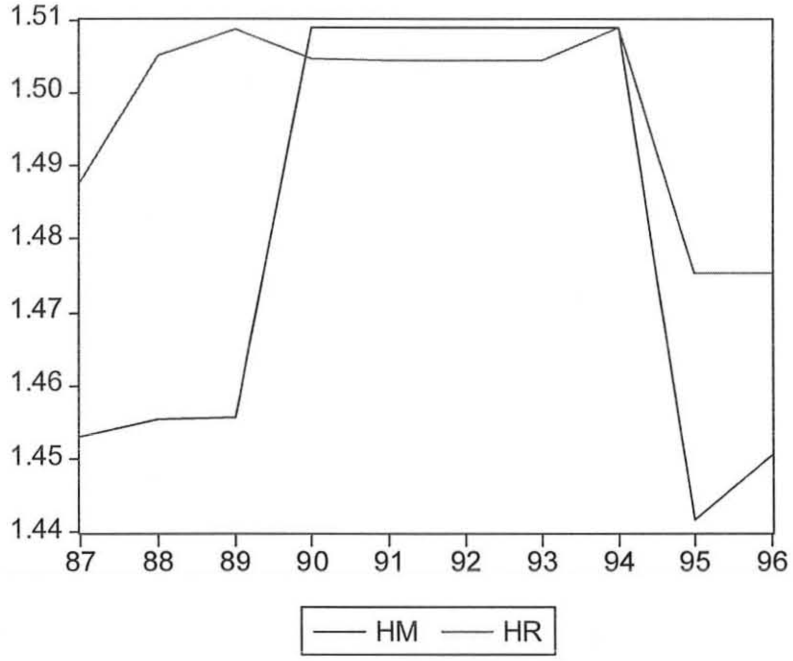
Appendix II Figure 1



Source: own competition

Appendix II. Figure 2

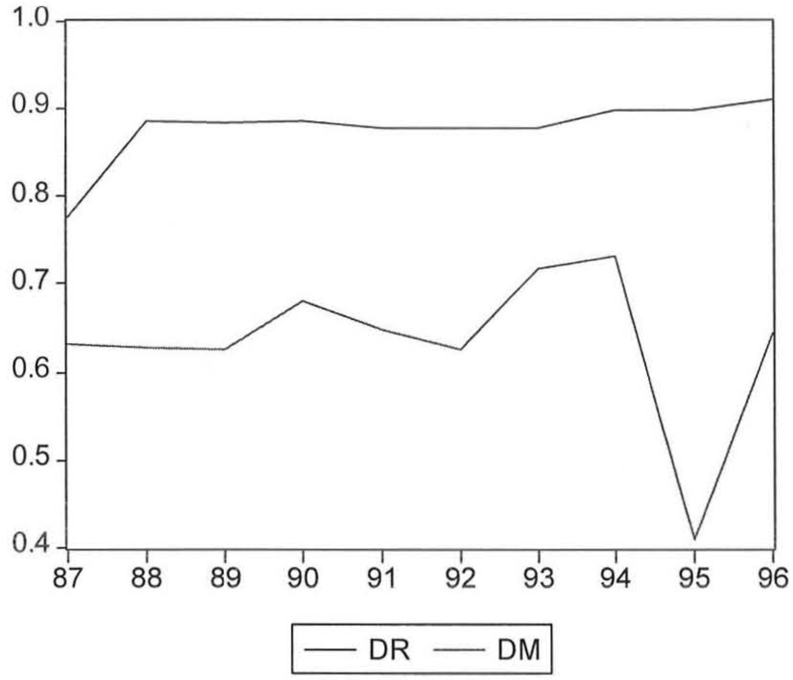
SHANON INDEX FOR MOTORIZED AND REED BOATS



Source: own competition

Appendix II. Figure 3

SIMPSON INDEX FOR MOTORIZED AND REED BOATS



Source: own competition

Appendix III

Questionnaires format

1. Questionnaire for fishers
2. Questionnaire for sellers

1. For Fishers

Date ___________________________

Name of area/village

1.1 Personal information

Name ______________________

Kebele ______________________

Wereda ____________________

Respondent Ethnic group _______________

Sex M ______ F _______

Marital status: Single ______ Married _____ Divorced ______

No of household ___________

Level of income _____________

Source of income:

Activities	Primary	Secondary	Tertiary
Agriculture			
Animal raring			
Mixed farming			
Trade			
Fishing			

Percent income from

Major occupation ___________________________________

Minor occupation ___________________________________

If the individual activities are more than are if agriculture, where _______________________

Near the lake _________________

Far from _____________________

Do you use irrigation near the lake?

Yes __________ No __________ How many meters far from the Lake

1.2 Fishery activity

When did you start fishing (year) _________________________?

Employment status: full time ___________, part time , _________ occasional __________________ only during fasting season

1. Type of gear used: Gillnet _________, long time, hook & time ___________ Beach seine ___________, traps, _________, scoop nets _____________ other specify _________________

2. Type of vessel used: motorized boat steel ___________, wooden boats Reed boat ________ others specify ______________

3 Type of fishing activity: full time ________________ part time ________________

4 Source of finance of boator gear ___________ others specify ____________ own save _________________

How much do you sell the fish

Per piece ____________

Per k/g ______________

When is the price of fish is high during fasting time _______________

Other time _________________

5 How long the fishing take per trip /days/

6 Fishing trip

- O Per month ___________
- 0 Per year ________________
- o Per season _____________

7 Catch per trip ________________

9 Catch per day ________________

8 Which kind of fish species do you harvest and Purpose of fishing

9 Self consumption ___________________

10 arket sale ________________________

11 Border (if there is)

Which kind of species do you consume & why?

____

When do you consume? _________________________________

Every day, ______________ occasionally ___________ during fasting period __________________

12 If are you member of the fisherman organization?

Yes __________________ No _______________

13 Cooperative ______________ non cooperative ____________

If cooperative member

Your responsibility in cooperatives

How much income do you get among the members

____

What kind of regulations do you use

Cost & source of fishing vessel ________________ maintenance of gear ______________

Other cost eg. Fuel, oil, crew & food _____________ others _________________

Fishing crew composition

14 o of members by type of Graft gear
15 15Age __________ Sex: M __________ F __________
16 Family members __________ hired laborers ____________

Market

Where do you sell your fish?
At landing easer site__________________
Type of customer: private consumer __________ Restaurants __________
Retailers _____________ private whole salers, fish corporatie sale at market:
distance to market __________________
Mode of transportation to market used ________________________

17 Trend of fishing efforts in the village
- o Have the No of boats increased or decreased over 10 years? increase ____________ decrease ____________ why __________________
- o Did the number of gear increased/decreased
- o Type of gear /if changed/________________________

Attitude towards fishing & _________
18 Harder or easier work than agriculture: _____________
why _____________________
19 Less or more income from agriculture: ______________
why ______________________
20 Less fish available than before: which species _______________
21 Credit by gov't: less or no____________ why _______________
22 Lack of availability of fishing gear ____________________
23 Problem in your fishing activity _______________________
24 Change of living standard after your ion to the fish industry

____
25 Factors for fish management ________________________ solutions that have been tried before, if any ____________________ what was positive result ____________________ what was the negative result ____________________
26 Suggested by authorities ____________________________
27 What is your opinion in sustainable management of fish resource
28 Who should take the responsiblity?
Fishers __________________ Community ______________
Government ______________
29 Any additional comment ________________________

Appendix IV CHEKLIST

OBJECTIVE	TYPE OF INFORMATION REQUARED	SOURCE OF INFORMATION	TECHNIQUE OF DATA COLLECTION
-Literature key source of theoretical frame work about fishery dev't &understand concept	-International literature -emprical literature Theoretical literature	-resource economics books -FAO papers	
-MSY, -optimum& -open-access solutions -actual harvest	-effort, catch,r,k,q -level of stock(x) -average price of fish -average cost of effort	-94-96 LFDP data -97-04LFDP -2005 data	-MOA sec. data -MOA sec. data -primary data(questionare)
-causes of deviation optimum from actual	-type of fish catch technology -type of property right regime -emp't policy	-region 3 Research center -fishery project plan - >> >>	
-to identify policy option	-Economic incentives tax,licencing,property right, tradable quota -command &control ban kind of gear, seasonal close	-fromLDC'sexprience	

Appendix V

1) Motorized survey (tone) RESULT

Y/E= U = 0.019418 - 0.00000318 E where q= 0.00024

$$K_m = a/q = \frac{0.019418}{0.00024} = 80$$

$$r_m = \frac{q2k}{b} = \frac{(0.00024k)2(80)}{0.00000318} = \frac{0.00000057(80)}{0.00000318} = \frac{0.000004608}{0.00000312} = 1.449$$

$$E_{msy} = r/2q = r/2q = \frac{1.449}{2(0.00024)} = \frac{1.449}{0.00048} = 3018.75$$

X_{MSY} = k/2 = 80/2 = 40

$$Y_{msy} = \frac{1.449(80)}{4} = 28.98$$

2) Reed boat survey (tone)

Y/E = u= 0.004785-0.0000000728E

$$K_{RB} = \frac{a}{q} = \frac{0.004785}{0.0000180} = 265.8$$

$$r_{RB} = \frac{q2k}{b} \frac{(0.0000180)2(265.8)}{0.0000000728} = 1.182$$

$$E_{msy} = \frac{r}{2q} = \frac{1.182}{2(0.000018)} = 32{,}833$$

X_{MSY} = 265.8/2=132.9

$$Y_{msy=} \frac{rk}{4} = \frac{1.182(265.8)}{4} = 78.54$$

3) Motorized boat (open-access solution)

$$X\infty = \frac{c}{pq} = \frac{50}{3400(0.00024)} = \frac{50}{0.816} = 61.27$$

where, q = 0.00024

$$Y\infty = rX\infty(1 - X\infty / k) = 1.449(61.27)\frac{(1-61.27)}{80} = (88.78)1\text{-}0.766) = 20.77$$

$$E\infty = \frac{Y\infty}{qx\infty} = \frac{20.77}{0.000024(61.27)} = \frac{20.77}{0.0147048} = 1412.5$$

4) Motorized optimum solution assume δ =0

$$X^* = \frac{k}{4}[(\frac{c}{pqk} + 1 - \frac{\delta}{r}) + \sqrt{(\frac{c}{pqk} + 1 - \frac{\delta}{r})2 + \frac{8c\delta}{pqkr}}]$$

$$= \frac{80}{4}[(\frac{50}{3400(0.00024)80)} + 1 + \sqrt{((\frac{50}{3400(0.00024)80)}) + 1)2}$$

$$= 20\ [(\frac{50}{65.28}) + 1) + \frac{50}{65.28} + 1$$

$$= 20\ [(1.77+1.77)] = 70.8$$

$$Y^* = rx^*(\frac{1 - x/k}{k}) = 1.449(70.8)(\frac{1-70.8}{80}) = 102.59(0.115) = 12$$

$$E^* = Y^*/qx^* \frac{12}{0.00024(70.8)} = \frac{12}{0.016992} = 706$$

5) Reed boat (open-access solution) where p=3450, c=12

$$X_\infty = \frac{12}{0.0000180(3450)} = \frac{12}{0.0621} = 193.24$$

where q=0.000018

r=1.182

$$Y\infty = rx\infty(1 - \frac{x\infty}{k}) = 1.182\ (193.24)\ (1 - \frac{193.24}{265}) = 228.41\ (0.27) = 61.85$$

$$E_\infty = \frac{Y\infty}{qx\infty} = \frac{61.85}{0.000018(193.24)} = \frac{61.85}{0.00347832} = 17{,}782$$

6) Reed boat optimum solution

$$X^* = \frac{k}{4}[(\frac{c}{pqk}+1-\frac{\delta}{r})+\sqrt{(\frac{c}{pqk}+1-\frac{\delta}{r})2+\frac{8c\delta}{pqkr}}$$

$$= \frac{265.8}{4}[(\frac{12}{3450(0.000018)265})+1(\frac{12}{3450(0.000018)265.8})+1$$

$$= 66.45[(\frac{12}{16.50618}+1)+\frac{12}{16.50618}+1)] = 66.45(1.727+1.727) = \underline{229.52}$$

$$Y^* = 1.182(229.52)\ (1-\frac{229.52}{265.8}) = 271.29(0.136493604) = \underline{37.03}$$

$$E^* = Y^*/qx^* = \frac{37.03}{0.000018(229.52)} = \frac{37.03}{0.00413136} = 8963$$

7) Reed boat result

Optimum solution

$$\pi = PY\text{-}(c/qx)\ Y$$

$$= 3450(37.03) - (\frac{12}{0.000018(229.52)})37.03$$

= 127,75..50-107, 567, 175

= 20,186

Msy solution

$$\pi = 3450(78.54) - [\frac{12}{0.000018(132.9)}]78.54$$

= 270,963 - 393,988.44

= -123,025.44

8) Motorized boat result

Optimum solution

$$\pi = py - (c/qx)y$$

$$= 3400(12) - (\frac{50}{0.00024(70.8})12$$

$$= 40{,}000 - 2943$$

$$= 37{,}857.09$$

Msy solution

$$\pi = 3400(28.98) - (\frac{50}{0.00024(40)})28.98$$

$$= 98532$$

$$= 98{,}532 - 150{,}937.5 \qquad \text{Loss} = 52{,}405.5$$

Declaration

I, the undersigned, declare that this thesis is my original work, has never been presented for a degree in any other university and that all source of materials used for this thesis have been dully acknowledged.

Declared by:
Abraham Ghirmai
Candidate
Signature ____________
Date: July 4, 2005

Confirmed by:
Dr. Dejene Aredo
Advisor
Signature ____________
Date: July 4, 2005

Place and date of submission: Addis Ababa University, July 4, 2005