THE STATUS OF FISHERIES IN JEBAL AULIA RESERVOIR AREA

With Special Emphasis on The Impact of Fishing on Fish Diversity

BY

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Dedication

1. ***To*** my parents who gave and gave without expecting any rewared.
2. ***To*** my family who kept supporting me and availing all assistance
3. needed.
4. ***To*** my friends who exerted every effort and if I am to mention a
5. name it will be (Amna.).
6. ***To*** all those whom I love…

7. ***….. I gratefully and respectfully dedicate this research …..***

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26.

27.

28. Abstract

29. The study was conducted in Jebal Aulia area, which is extended 9 km north of the dam and 4 km southwards. In order to investigate if there is over-fishing and if so try to measure the economic impact resulting thereafter.

30. 60 fishermen were randomly selected. The data were collected using a two type of questionnaires; the first about the socio-economic characteristics of fish production and fishermen in the area and the selected sample was interviewed. The second about the average length of fish for some species. Further formal meetings with administrative personnel were conducted in addition to the secondary data collected from books, references, and relevant bodies.

31. The study proved that the status of Jebal Aulia fishery was depleted and the actual production of the area was exceed the optimal one and that has negatively affected fish resources through:-

32. a) Decline in production rate compared to previous years;

33. b) Change in fish structure was noticed and also scarcity of some

34. species of fish.

35. c) And duly the sizes of all targeted species significantly decreased.

36. The study also proved that the water level has no effect on the low rate of production in the area. The number of fishermen who practiced fishing illegally is (42) from total (60), which reflected on the sharp difference of lengths of targeted species from the legal length eg. Egel was 19 cm, Dibis was 17 cm, Cas and Kwara were 10 cm.

37. As Jebal Aulia area has recently prospered because of the dam attraction of sizable number of tourists and thus offering new job

opportunities, resulting on an increase in population intensity. This might be regarded as one of the causes leading to overfishing. Accordingly, suitable policies should be tailored to achieve the previous plans and goals with ultimate targets of maintaining a sustainable way of conserving fish resources. Polices and plans could be feasible if the following measures Would be respected:-

- Implementation should be meant to improve fishing management and conservation.
- Fishing societies should act in coordination with other environmental societies, such as land and soil fertility conservation societies, forest protection and improvement societies and finally water and sanitation societies.
- Research on fish biodiversity should be encouraged and improved , because our libraries lack such studies.

38.

ملخص البحث

أجريت الدراسة فى منطقة جبل أولياء والتى تشتـمل على (١٣ كم طولى) "٩ كم شمال الخزان و ٤ كم" جنوب الخزان لتوضيح الآثار الناتجة عن الصيد على التنوع الإحيائى للأسماك بالمنطقة بجانب الآثار الاقتصادية.

أخذت العينة عشوائياً وكان حجمها "٦٠" صياد شمال وجنوب الخـ ـزان. تم تجميع البيانات عن طريق نوعين من الإستبيان الاول عن البيانات الاقتصادية الاجتماعية لانتاج المصيد السمكى بمنطقة جبل اولياء والثانى لمعرفة متوسط الاطوال السمكية لبعض الانواع. بالإضافة الى الاجتماعات الرسمية مع بعض المسئولين بالمنطقة وأيضاً عن طريق البيانات الثانوية من الكتب والمراجع والمؤسسات ذات الصلة.

أوضحت الدراسة أن الصيد فى منطقة جبل اولياء يمكن وصفه بالصيد الجائر أو المفرط حيث فاق الانتاج الفعلى الانتاج الامثل بمقدار اربع مرات،مما ادى الى استنزاف المورد وقد تبينت الآثار السالبة على الموارد السمكية بالمنطقة والتى نتجت عن ذلك فى الآتى:

٣٩. تناقص معدلات الإنتاج مقارنة بالسنوات السابقة.

٤٠. التغيير فى التركيبة السمكية وندرة بعض الأنواع.

٤١. صغر حجم الأسماك المستهدفة بالصيد وتناقص أطوالها.

أوضحت الدراسة ان مستوى المياه ليس له دور فى تناقص معدلات الانتاج.كما بلغ عدد الصيادين الذين يمارسون الصيد بطريقة غير قانونية ٤٢ صياد من جملة٦٠ صيادوانعكس ذلك فى اختلاف الاطوال السمكية بصورة حادة عن الاطوال القانونية لها فمثلا بلغ طول العجل ١٩ سم والدبس ١٧سم والكوارا والكاس ١٠سم.

منطقة جبل أولياء من المناطق التى نمت وإزدهرت بوجود الخزان والذى كان السبب الأول فى جذب عدد كبير من السياح مما أدى الى توفير فرص عمل كثيرة والتى قد تكون من الأسباب التى ساهمت فى وجود ظاهرة الصيد المفرط بالمنطقة.

لذلك نوصى بوضع سياسات وخطط لتحقيق إستدامة الموارد السمكية وصيانتها من الانقراض وتكون هذه السياسات أكثر ملائمة ووضوح إذا تم إعتبار النواحى التالية:

١. إذا قصد بتلك السياسات تحسين إدارة المصيد السمكى.

٢. تكوين جمعيات للصيادين بالتنسيق مع الجمعيات الأخرى ذات الصلة كجمعية حماية البيئة-جمعية صحة المياه ..الخ.
٣. تشجيع وتحسين البحوث فى مجال التنوع الإحيائى خاصة فى مجال المصائد السمكية وذلك لفقر مكتباتنا لهذا النوع من الدراسات.

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Chapter One

1. Introduction and Historical background

1.1 Introduction:

Biodiversity is fundamental to the functioning and resilience of freshwater ecosystem, many of which supply goods and services that are important for human welfare. However, economic utilization of such systems may lead to biodiversity loss either directly through over-exploitation or indirectly through habitat destruction. The fundamental problem of biodiversity conservation is to maintain that level of biodiversity, which will guarantee the functioning of ecosystems on which human consumption and production depend. (Perrings, 1995)

The main driving force behind biodiversity loss stems from human activities. It is possible to distinguish proximate and underlying causes. Proximate causes include the direct overexploitation of species, for example through hunting, fishing and collecting or gathering and their indirect impact on ecosystem degradation that leads to species loss. Habitat destruction and conversion can be given as examples. (Heywood, 1995).

Overfishing causes a reduction in the size and age of fish in the catch, and alters the genetic structure of the stock. This is because fishing adds to the natural mortality of species and so decreases the average life span (Kasulo, 2000).

1.2. Historical background

From ancient times fishing, like other hunting activities, has been a major source of food for humanity (Souma, 1989).

Studies in fishing in ancient Egypt revealed some important information about fishing implements and hunting activities that were similar to those which are still used by the Nilotic people and Zande (Bates, 1917). And according to Motagio's study of hunting tools and weapons of the early Man of Mesolithic period (1882), many of the fishing tools and fishing methods are so similar to each other along the historical ages in many parts of the world. (Macopongy, 1980) said that excavation of relics of El Shehenab (40 miles north of Omdurman), reveals the existence of hooks made of bones during the Neolithic period in that area. Fishing nets are recent in comparison to hooks and this may be due to the fact that fishnets are more complicated and difficult to make than hooks. May be the earliest and simplest type of gill net were the ones described by Bates in 1917.

Most of developing countries depend mainly on their resource endowments for production and food security. Thus excessive degradation of natural resources would limit their chances for sustainable development.

Accordingly, environmental degradation in its many forms constituted threat to the economic development, growth, food security and quality of life of Sudanese people (Hamid, 2000).

Environmental conservation is important for maintaining the natural resources for their continued economic development and existence.

In recent years, how to attain food security has become a matter of great concern worldwide.

1.3. Fish as a source of food

Fish plays a vital role in feeding the world's population. Recent global statistics reveal wide variations in fish consumption, but people in

developing countries are generally much more dependent on fish as a part of their daily diets than people in developed world. It may be used fresh, frozen, canned, cured salted, dried or smoked. Fishmeal and fish flour are two products of the fishing industry used for the dairy animals and poultry feeds and so add to the world's supply of protein rich food. Also they can be used for human consumption with excellent Nutrient content when prepared from small fish (Patti, 1989).

Fish is an important and highly desirable food for people suffering from protein-energy malnutrition, which is a leading cause of infant mortality in the developing world. It can be a valuable force against endemic goiter caused by lack of dietary iron and iodine. Each 100 grams of lean or white fish contains less than 1% of fat, about 18% of protein and energy value range of 50-80 k cal. Oily fish contains 8-15% of fat and so have a higher energy value (80-160 kcal/100 g).

When processed, preserved and cooked properly, fish retains most of its high nutrient content. However this can be lost during poor handling and storage. Fish protein has a high biological value similar to the protein of land animals but the contents of protein are somewhat less than meat, and there is often a large waste in the scales and bones.

Marine fish are rich source of iodine in the diet and a good source of fluoride. Small fish may be useful source of calcium when eaten as a whole together with the bones (Pass More And East Wood, 1986).

Table (1.1): Comparison between the average amount of protein and calories from fish and other animals or animal products per 100 grams.

Source	Amount of protein	Amount of calories
Fish	**18**	**120**
Poultry	**19**	**100**
Beef	**20**	**310**
Eggs	**13**	**160**
Milk	**4**	**60**

(**Source:** strategy and action program for fisheries FAO publications 1989, Rome).

Looking at history the observations that the more physical presence of food stocks does not in any way constitute food security for families belonging to those vulnerable groups. What is important is the people purchasing power and price stability. This is true both within a country and at national and international level. Hence the conviction is that food security is a public good: if it is ensured, every body will get benefits (FAO, 1996).

1.4. The nature of fishing in Sudan

Fishermen are considered in most of the developing countries as one of the most neglected and poorest groups within society. Having traditional

inherited fishing methods that are not adapted to modern fishing methods, gears, fish handling and preservation. Actually, the same conditions are prevailing in Sudan and thus there is a huge gap between the world modern fisheries and the traditional fisheries of the country.

Fishing boats in Sudan are mostly wooden canoes with few steel and fiberglass boats. Generally, there is low motorization level and most engines are in fact used by fish collecting boat and seldom engaged in fishing operations (Bellemans and Khalid, 1998).

Based on estimated annual catch of 1995 of the White Nile the average catch per fisherman reached 1.6 tons a year while the average catch per fishing vessel was 3.9 tons. The average size of crew per fishing vessel ranges between 2-3 persons (calculated by author).

The main types of fishing gear are fishing nets with occasional use of long lines (Sarema). Some times the different types of nets are the same in the making with only difference in application. Their material is often nylon twin but in some area nylon monofilament is also found. Fishing nets are imported, as there is no local product.

The beach facilities which include clean water, ice factories, cold stores, processing units and marketing facilities are of the most important services that should be provided for fishermen and their boats at the landing areas, all of which some are hardly availed making most of the landing sites in real need of vital fishing facilities (Moursy, 1987).

Fish processing in Sudan is limited to traditional methods of drying and salting. The production of frozen fish fillets is only limited to fish exporters and no fish canning industry exists in Sudan. Table (1.2) shows the

exported quantities of fish and wet-salted fish (Fassikh) during the period (1992-1997). Fish consumption in Sudan is generally concentrated in towns and coastal area of marine and inland waters. Total consumption is affected by the consumer's preference to fresh fishes rather than frozen.

Table (1.2): Exports of fresh and wet-salted fish (Fasseikh) during the period 1991-1997. (Quty. in Tons)

Year	***Fresh***	***wet-salted***
1991	**-**	**129**
1992	**-**	**39**
1993	**-**	**-**
1994	**26**	**-**
1995	**103**	**-**
1996	**162**	**-**
1997	**136**	**-**

(Source: Foreign Trade Statistical Digests, Bank of Sudan, 1991-97).

The per capita consumption of fish in Sudan is about 1.3 kg/year and it is considered very low when compared to the international level, which is about 13 kg/year according to FAO statistics. Table (1.4) shows the consumed fish quantities in Sudan (The fishery department takes into account the quantities of fish losses when calculating statistics of the

produced and marketed quantities). Khartoum is considered the main fish marketing area. The daily supply (according to Khartoum State Fishery Department, 1997) is about 15 tons and the annual supply is estimated at 5400 tons. The marketing services are traditional and inefficient resulting in the waste of a large portion of the total production in addition to the use of non-insulated trucks for fish transportation and the unavailability of other preservation facilities.

Table (1.3): **Total fish consumed in Sudan, 1987-1997 (Quantities in 000 tons)**

Year	Local production	Imported quantities	*Total*
1987	**29.2**	**1.109**	**30.309**
1988	**29.6**	**0.046**	**29.646**
1989	**28.0**	**0.007**	**28.007**
1990	**29.0**	**0.010**	**29.010**
1991	**31.0**	**0.014**	**31.014**
1992	**34.9**	**0.042**	**34.942**
1993	**36.0**	**-**	**36.000**
1994	**40.0**	**0.023**	**40.023**
1995	**44.9**	**0.048**	**44.948**
1996	**49.8**	**0.094**	**49.894**
1997	*** 54.9**	*** 0.040**	*** 54.940**

* Estimated- (**Source:** Fishery Department 1997).

1.2. Problem statement and justification

Sudan is endowed with vast inland and marine water containing about 110 thousand tons of fish stock. Low productivity of human and human resources in addition to the imbalance of food supply and its increasing demand resulting from the rapid increase in the population of the country lead to give the priority to food security issue, in which the fishery sector can play an important role. The questions are: could fishery sector satisfy this demand? How could fish production contribute to attain food security?. And what are the reasons behind the decline in the yield?.

Capture fisheries based on species that are presently exploited seem to have reached their natural limits. In fact, the challenge is to sustain levels of production in a situation where the majority of fish stocks are either fully exploited or overexploited. Without a reduction in fishing effort and improving management, the prospect for achieving sustainable fisheries is not suitable FAO (pinhciro, 1996).

The implementation of different fishing regulations in Sudan face certain obstacles to the extent that, the present situation is more similar to that of an open access fisheries than that of regulated one.

On the other hand, fisheries administration, which is responsible for the conservation of resources through rationalizing the fishing efforts, also faces problems such as monitoring and regulation of the different fishing activities (Fisheries Department, 2004 Seminar).

The study tries to find some indicators that might help measuring fishery situation i.e. over- stocking or depletion. It could be mentioned that many data of fishing show that the demand of fish is increasing from time to time, and over- fishing may be expected.

Also attempts to show what the main constraints that hinder the implementation of fishing regulation in (Jebal Aulia area) are.

1.3. Objectives of the study

The broad objective is to study the main reasons behind the degradation in fishery resource. At the same time tries to find an answer to the question if this degradation could be attributed to irrational human activities. And if so measure its adverse effect on the aquatic life such as changing fish structure, size and yield result in low harvesting and production at White Nile (Jebal Aulia). Specifically the study is intended to:

1. Determine some of the socio-economic characteristics of fishermen in the area that draw their main features.
2. Envisage some indications (fish structure and fish production) and determine indicators of fish status in Jebal Aulia area (depletion or under utilization) that result from environmental changes and human activities.
3. Show the main constraints hindering the implementation of fisheries regulation in White Nile Jebal Aulia area.

1.7. Hypotheses:

1. Many unknown socioeconomic aspects of fishermen such as (age, education, marital status and experience) affect the problem of implementing fisheries regulation in Jebal Aulia area.
2. If the restocking rate of (type, size or fish population as a whole) is less than the off-take (yield for the same period) then the result is depletion.
3. The regulations that control the management process of fishing are theoretically very sound the hypothesis would like to investigate the real causes that make its implementation infeasible.

1.5. Research Methodology

1.5.1 Sampling technique and sample size determination

Primary and secondary data will be used in the analysis for testing the above hypotheses. Primary data will be collected through direct survey using two types of questionnaires. One for the fishermen and the other designed for fish's average length, which is conduct in marketing areas. Samples are selected randomly and sample size of 60 respondents were determined according to the following formula:

$n= k^2v^2/D^2$

Where:

n= sample size

K= z value (the normal deviation at 0.95 probability)

v= the estimated standard deviation of output

D= the magnitude of the difference to be detected (the acceptable error assumed is .04)

Secondary data will be collected from institutions that are related to the fishery sector or relevant sources such as:

- Ministry of Agriculture and Animal Wealth
- Ministry of Irrigation
- University of Juba
- Fisheries Department
- Fisheries Statistics Center

- Fisheries Regulation Office

1.5.2 Suggested Methods of analysis:

The diverse objectives require the use of different empirical and analytical techniques. There are many types of techniques such as:

1. The trends of fish production: to see how production decreases or increases through different years. Also the trend analysis of CPUE (Catch Per Unit Effort) through the same period.
2. Using correlation analysis one can see the effect of water level up and downstream on production in the same years. To determine the reason behind the decline catch (Ecological, economical factors).
3. To compare the legal mean of length of some species (that mentioned in fisheries low document) with the actual length of the same species found in the landing area (measured by the interviewer) and see the difference.
4. To envisage some indications (fish structure and fish production), and the correlation analysis of production as dependent factor and other independent factors (number of boats, CPUE).
5. To explain the results of illegal human activities such as (time and season of fishing, type of nets according to mesh size …etc).
6. To estimate the level of maximum sustainable yield (MSY) and optimal efforts (OE) of Jebal Aulia area by using the surplus production model; and determine if there is depletion.
7. For regulation issues, to show the description of traditional management policies (gear restriction, closed season and licensing), and what the constraints of implementing these policies are.

1.5.3 Organization of the study

The study consists of five chapters:

Chapter one is an introduction. It includes the importance of the problem, objectives and hypotheses to be tested in addition to the description of the area of study and methodology.

Chapter two is a review of available literature on the fishing industry, (fish production, environmental concepts related to fishery, fish structure, fish depletion and fish management).

Chapter three presents the descriptive socioeconomic characteristics of fishermen and their relation to fishing harvest.

A chapter four presents the methods used to analyze the data, besides the findings and results.

Chapter five is the summary of the study, the conclusion drawn and discussion and recommendations suggested for the production of fish at Jebal Aulia area.

1.6 The study Area:

Jebal Aulia reservoir extends for 629 km south of the dam site. It is considered one of the important areas for fish production in Sudan as it contributes more than 26% of the total production of this commodity in the country (Fishery Department Statistics, 1995). And all the results of scientific researches, confirmed that this reservoir is endowed with ecological factors, which enable it to give high productivity.

The North Jebal Aulia area and Jebal Aulia Lake provide half of the fish production of the State. Thus, the supply to Khartoum State is estimated at 7,000 tons annually. This leads to a high demand for this commodity, which satisfies some needs and bridges the gap of deficiency of food materials. The State contributes 12.5% of the demand.

1.6.1 location of Jebal Aulia Area:

13 km (9 km north and 4km south of the Dam). This area is located on the White Nile, in Greater Khartoum Area. It extends northward up to Fitaih Al-Agaliyeen; and southward up to Albeja Abdel Hadi and Shigailab area.
Population: 450,000 persons.

1.6.2 Social situation:

The local population is a mixture of tribes of the northern, western and southern regions of Sudan. From the northern region, there are AL-Mahas, Danagla, Rubatab, Jaaliyeen and Shaygiya. In the last few years, the area witnessed

a marked increase in population, as a result of the displacement of southerners in Dar AL-Slam settlement camp (and the newly named Bantue area). This led to some economic changes in the area.

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1.6.3 The Social Structure, Relations and the Population ties:

The main occupations of population are (Farmers, craftsmen, merchants, workers and officials) in addition to fishing in its many types.

Population of Jebal Aulia came to the area since the construction of the Dam, in 1933. Then they intermarried and merged to become one community. Their strong attachment gives an indicator of strong social ties. It has a number of clubs, social centers, Khalwas, charity societies and mosques.

1.6.4 The Current Projects and Construction in the Area

Jebal Aulia area accommodates all the following bodies:-

Al-Butana Dairy Products, the Poultry project, (the Junction of the two Niles), Fodder factory, Khartoum Fish Company, Huda Fish Factory, the Marine Products Company and a fish farm of the Fishery College of

AL Nilein University Jebal Aulia Dam Administration, the Government Offices under Jebal Aulia Locality (Court- Police - Schools - University),

a civilian teaching hospital, veterinary hospital, Fish Administration Office, kindergartens, ‘Khalwas’, mosques, Jebal Aulia market, Dar Al-Salam Market, satellites Station (at Abu Haraz), electricity generation station from the Dam, the Electric Energy training Institute, health centers for every village, a football stadium, agricultural schemes, artisan wells in each village, transport facilities between villages and gas station.

1.6.5 Fish Production and per capita income

Jebal Aulia area is the most productive fish landing areas; as this is estimated at 517,416 kg (Fisheries department, 2004). This estimated quantity is considered non-realistic, for the following reasons:

1. The available means of transport don't satisfy the required conditions for chill and insulated isolation trucks. This causes Losses in production.
2. The fish landing areas are not fully monitored; and their real production is not known, because most consumption is local, while some types are marketed in branch markets.
3. There are some popular dishes; which are high preferred and they are prepared at home, such as, the salted fish (faseehk), (Tarkeen) and small fish (seer). In addition, there is the (mandasha), which accompanied the settlement of the southern tribes and became a main dish for them. All these types of foods are not included in Productivity.
4. Usually fish catches after the morning hours are not regarded, also.

It is thus evident that the estimated production is not realistic. The actual production is much larger, for the above-mentioned reasons and if compared to the average per capita income is SDD 20,000 per month (SDD=Sudanese Dinars).

1.6.6 The Structure, Methods and Fishing techniques

The number of boats in Jebal Aulia area is 92. They carry 217 fishing nets. The number of fishermen is 230 (fisheries department 2004). The prevailing methods of fishing are:

AL-Tarraha (cast net) and beach seines. The types of the existing nets are: The gill net, the hand lines, the trowels and the silka. Most of these nets are not legal, because of the non-legality of mesh size as it is explained below.

1.6.6.1 Fishing gear

Fishing gear commonly used on the Jebal Aulia reservoir can be classified into gillnets, trammels net, beach seines, baited and unbaited long lines, cast net and traps:

Trammel nets: locally called monofilament nets or silka, though prohibited, are being imported illegally and commonly used, especially in the area near to the dam.

Gillnets: several types of gillnets can be distinguished with stretched mesh sizes ranging from 60 to 160 mm for the larger species. At times, gillnets can be used as surrounding gillnets in combination with beating the water surface when placed near densely vegetated areas for catching Tilapia (***Oreochromis spp***). The fisheries law requires that the minimum allowed stretched mesh size for gillnets be of 100mm with twine not smaller than 210/6.

Bee-bee gillnets: these gillnets with mesh sizes ranging between 30 to 40 mm (twine 210/3 or4) are 100 to 500 meters long and have a 1.5 to 2 meters depth. They are being used in open waters night to target small fishes such as the characid ***Alestes dentex*** and ***Hydrocyonus forshali***, which make up

Fassiekh (wet salted, pressed and fermented whole small to large fish). The bee-bee gillnets are being used all year round with an exception during the rainy season, when catches decrease and fishermen use larger mesh gillnets.

Cast nets: these nets operated from the downstream side of the dam itself and along the fish ladder or from non-motorized canoes, which are very popular in the dam area. Many foot fishermen also use this gear from the shoreline.

Beach seines: two main type of beach seines can be distinguished: the normally 500 meter long beach seines ("Umsura") and the large sized beach seines.

("Umkubuk") with several pieces of nets ranging from large mesh size in the middle to small along the aisles. In order to increase catches, fishermen often spread, two to three hours before the actual operation, sorgham Dura" grains along the targeted shoreline.

Longlines: two main types of longlines are being used, the unbaited long lines ("Jigho") where the line is densely furnished with a large number of unbaited hooks for entangling fish swimming in the neighborhood and baited loglines ("Sareema") carrying around 100-150 hook spear line, placed at a distance of about 1 meter from each other, targeting mainly *Lates* ***niloticus***. the (mainly live) bait consists of small (cat) fishes caught with small beach seines in neighboring khors.(FAO report 1997).

1.6.7 Fish Species:

There are about 25 types or species of fish: the ***Telapia zilli., Labes niloticus, Bagruys Bayad, Synodontis sp., Clarias Lazera, Barbus bynnie***, ***Alestes dentex., Hydrocynus forskali***. and ***Mormyrus caschive***. The average weight of the landed fish varies between 200-3000 grm. The average lengths

of the commercial fish are: ***Barbus bynnie*** - 19-72 cms; ***Bagrus bayad*** — 31 —70 cms; ***Telapia zilli***.- 8-34 cms; ***Labeo niloticus***. *17-59* cms.

1.6.8 Home Processing of Fish

Owing to the social change, which is witnessed by the region in the last few years, major economic changes occurred. Of these the following are the most important:-

1- Changes in the food consumption habits, to popular meals, which are represented by displaced people. As an example, 'AL-Mandasha' and small fish (seer). There grew, thus, a high demand for these types; especially that they are cheap in price.

2- The displaced people from Khartoum to Jebal Aulia area, preferred to abandon their work in Khartoum and depend on fishing as their main occupation. This is due to its ease and nearness to the Dam. By so doing they spare the cost of transport to Khartoum.

3- Many of the government officials practice fishing, as a secondary occupation.

4- Female households practice fish processing in an illegal way (salted fish 'Faseekh', 'Tarken', small fish (seer); and without any administrative controls.

Table (1.4) shows the most popular meals, their names and the type of fish from which they are processed:

Table (1.4) species commonly used in home meals and their prices.

Name of meal	Type of Fish used	Sale Unit	Price (SD)
1- Terkeen	***Hydrocynus forkhali, Alestes dentex. Alestes nurse, Labeo niloticus.***	**Tin**	**6,000**
2- salted Fish (Faseekh)	***Hydrocyonus forskal , Alestes dentex.***	**Canned Tin**	**250**
3- Mandasha	***Alestes dentex.***	**Pot (kora)**	**50**
4- small fish (seer)	***Alestes dentex .***	**plate**	**50**

(Source: Jebal Aulia regulation office 2005).

Faseekh and Terkin = Fermented

From the above table, it could be observed that the ***Alestes dentex*** is more targeted, together with the ***Hydroyorus forskali***. and then the ***labeo niloticus.***

Table (1.5) **The methods and instruments that are used to catch targeted species**

Type of net	Mech size	No. of threads	Type of thread	Method of fishing
Wire string	**Less than 4 cms**	**Single thread**	**Nylon string**	**Cast net, seine**
Nylon ring	**2cms or less**	**12,9,6, 4, 3,**	**Multi- filament**	**Bee Bee gillnets**

(Source: Jebal Aulia regulation office 2005).

It may be observed that all the above-mentioned methods and instruments of fishing are not legal, which threatens all those species with extinction.

1.6.9 Fishermen Society at Jebal Aulia Area

Acquiring fishing equipment may be considered the main problem facing fishermen; because of their high cost and their non- availability in the specifications favored by the fishermen, according to the season of the availability of fish in the specified period. For this cause, a cooperative society for fishermen was established in the first November 2002 to supply

them with fishing equipment by pre payment and in reasonable installments, (every 6 months). The number of fishermen in the society is, at present, 74 persons. The membership includes all those related to the fish field. The society also supplies the basic necessities of food for the member fishermen. Some times it offers them money loans. The determined subscription fees are SD 200/month.

The cost of nets: each boat has two nets. The cost of the two nets is SD 54,600. While the cost of a single net for the fisherman: SD 34,000.

The society's location is near the Dam, the rest house and the Irrigation Department Workshop. There is plenty of fish in this area, and which have an international reputation for good quantity and quality (Jebal Aulia regulation Office 2005).

Chapter Two

2.1 Literature Review

This chapter reviews the available and most relevant literature on fish production, environmental concepts related to fishing and fisheries, fish structure, fish depletion and its causes, and fish management.

2.1.1 Economic Importance

Fishes rank as one of the world's major food commodities. In 1996 the Food and Agriculture Organization of the United Nation (FAO) estimated the overall world production of fish at about 95 million tons as illustrated in table (2.1); 70% of world production is consumed as food, the balance is used for animal feeds and other purposes.

Table (2.1): The distribution of world catch according to the different usages.

Types of usage	Amount in million Tons	*Percent*	Percent of total *Production*
Human consumption fresh Frozen **Canned** **Cured**	**19.9** **22.0** **11.3** **13.3**	**30.00** **33.00** **17.00** **20.00**	**20.29** **23.16** **11.89** **14.00**
Sub-total	**66.5**	**100.00**	**70.00**
Other purposes Oils and meals **Miscellaneous**	**27.17** **1.33**	**95.33** **4.67**	**18.60** **1.40**
Sub-total	**28.5**	**100.00**	**30.00**
Total production/year	**95.000**		**100.00**

(Source : Fishery year book 1996, FAO).

30% of the total catch for human consumption is sold fresh, while 33% as frozen. The manufactured into canned products amounts to 17% and the balance (i.e. 20%) is processed as cured salted, dried or smoked etc.

The world fish production destined for direct human consumption has increased according to FAO statistics almost three times over the past 50 years.

Artisan fisheries which account for more than 25% of the world catch and 40% of total human fish consumption, is characterized by high levels of labor, low capital investment, low level of mechanization and frequent use of passive fishing methods (Patti, 1989).

2.1.1.2 Fish production in Sudan

The nature of fish industry of Sudan is divided into two main sectors, the inland fisheries (freshwater fisheries) and the marine fisheries of the Red Sea. The inland fisheries are composed of the main Nile and its tributaries which are 6500 km long, and specially the reservoirs formed by the dams on the rivers; Jebal Aulia reservoir on the white Nile, Rosaries and Sennar reservoirs on the Blue Nile, Khashm Algerba reservoir on Atbara river and Nuba lake, which is the Sudanese portion on lake Nasir's reservoir, which lies in the northern part of Sudan, and it was formed by the construction of the Egyptian High Dam south of Aswan. It is the richest source of fish in the main Nile inside the Sudan, in addition to the Sud region at upper White Nile.

On the other hand, the marine fisheries are at the Sudanese coastline on the Red Sea, which extends to 720 km, and a continental shelf of about 98,000 km^2, which is unsuitable for trawling due to its irregular coral beds (Souness, 1978). This area is endowed with fine fishes, shellfishes, "crab" and crustaceans "shrimps and lobsters" (Osman et al, 1990).

The total sustainable fish stock of Sudan is about 110,000 tons (fishery department statistics 1995). About 68% of this stock is found in the southern states and specially in the Sud region due the existence of favorable natural conditions for fish production and growth, where water covers about 2 million hectares (the total water area of Sudan is about 20 million hectares).

Fish composition in White Nile River

Table (2.2) Species commonly caught in J.A. dam

Scientific name	**Catch %**
Hydrocyonus forkhali	**10**
Chrysichthys auratus	**5.2**

Labeo horie	**5**
Alestes dentex	**4.8**
Eutropius niloticus	**4.6**
Telapia zillei - Oreochronus	**4.6**
Hydrocyonus lineatus	**4.4**

(Source: Rahaman, A. 1986)

2.1.1.3 The fish production in white Nile

Jebal Aulia reservoir stretches for over some 629 km, from the dam site down south to Renk. Detailed historical statistical data do not exist, however, various estimates were made of the yearly production. That mentioned by Hamid (2000) reported that "in 1975, annual production for reservoir has been estimated at 7.000-8.100 ton with potential yield of 15.000 ton, corresponding to 100 kg/ha/year. Rahman in (1985) estimated the maximum sustainable yield of the fishes for the whole reservoir to be 7364 tons /year, while FAO (1982) was estimated the production to be 8216 tons with a potential yield of 4500 tons or 30 kg/ha/year. It was calculated the annual yield of 55 kg/ha/year.

Bellemans and Khalid in (1998) estimated the production level of the entire reservoir ranges between 7000-8000 tons, although it is also being advocated that it could be as low as 4,500 to 5000 tons due to heavy fishing pressure, fish stock depletion and man-induced environmental disturbances. Also Bellemans and Khalid in 1998 estimated the production by stratum as follow:

Stratum 1, refers to fishing site from the dam to 25 km southwords covering Khartoum State.

Stratum 2, extends over about 125 km, from El Mansoorab to Edobasi.

Stratum 3, covers the distance over about 160 km, from Edueim to El Hidieb south Kosti.

Stratum 4 extends over about 110 km from El Hidieb to Juda

2.1.1.3 Food security and Natural Resources:

Feeding the world in 21st century will require not only food availability, but also food security: access to the food required for a healthy and productive life. It means the ability to grow and to purchase food as needed. It also means that people do not have to rely on staple food such as wheat, rice, potatoes and cassava.

In addition to the expected population growth, the FAO estimates as many 840 millions people, a number that exceeds the combined populations of Europe, the United States, Canada, and Japan –currently don't have enough to eat. The companion problem of hidden hunger, affects even more people in the developing world. The shift away from the traditional food staples will make this challenge even more difficult (Journal-World Fish Center 2002).

It is clear that all opportunities have to be taken to use all resources more efficiently, in both the short and long terms.

Optimizing our management of plant nutrients and water, taking advantage of the opportunities offered by genetic resources and improving the management of fishery resources. These efforts will cross boundaries between technical discipline and nations. Involvement is the key to sustainable use of the planet's natural resources. It only is achieved if farming, fishing and forest communities participate in seeking innovation and find in them the benefits that they need. Given the right incentives and

government support, they can make significant progress towards managing land water resources well. Jul-Lansen, (2003).

2.1.2 Environmental concepts

2.1.2.1 Environment

Environment is the sum of all-external forces or influences (for example, heat) that affect the life of an organism. In other words, it is a complex of many factors that interact not only with the organism but also among them selves (Billings, in 1976).

Brunt's (1987) defined environment as : “the environment is the entire physical and biological or natural resource ecosystem, which contacts with each other”. The physical factors and biological factors are listed in table (2.9)

Table (2.9) Environmental components

Physical factors	Biological factors
Energy	**Plants**
Radiation	**Animals**
Temperature and Heat flow	**Man**
Water	**Micro- organism**
Atmospheric gasses and wind	
Fire	
Topography	
Soil	

Source: W.D.Billings 1976, plants, man and ecosystem

“Environment as a set of phenomena and conditions that encompasses man, is the only thing which man seeks to accommodate himself by a proper exploitation of natural resources” (World Commission on Environment and Development (1990).

Boon in 1990 defined environment as: “the physical living and non-living surroundings of the people”. But the simplest and yet most comprehensive definition of environment is given by Mensah (1998)“environment is composed of the natural resources both biotic and biotic such as air, water, soil, fauna and flora and the interaction between them”. In this study Mensah’s definition will be adopted.

2.1.2.2 Open access fishery:

In open access fishery conditions, the resource as property does not exist, and thousands of members of the society could harvest the resource. This regime fails to lead to optimal resource allocation, and thus constitutes a sufficient condition for resource overexploitation. Two situations arise: unrestricted access to the resource and generation of externalities between resource users Benhin, (2004).

2.1.2.3 Externalities:

Are defined as every external effect caused by individual fishers but not included in their accounting system such as (factory waste water that affects the species in the area near the factory) . Fishing externalities are commonly negative and occur when fishers can freely enter and capture a resource, and where a voluntary agreement of co-operation does not exist; in these cases, resource users do not consider the external effect impose on others Benhin, (2004).

2.1.2.4 Fishing gears:

Hodgson, (1998) defines fishing gear, as any net, trap, sieve, line, spear or other implement or tool used for fishing and fishing effort is the number of fishermen and gears.

2.1.3. Global environmental degradation

Recently, environmental degradation has become the concern of industrialized as well as developing countries. Environmental conservation, far from being a luxury is an essential ingredient for maintaining the natural resource base upon which most nations depend for their continued sustainable economic development.

Environmental degradation in its many forms constitutes threat to economic growth and development. Many of environmental problems are blamed on the modern living pattern and human activities. Indeed, when the 20^{th} century began, neither human beings, nor human technology had the power to radically alter the global ecosystems and create interrelated problems on the entire earth (Hamid, 2000).

The common global environmental problems air and water pollution on an international scale, in the form of acid rain, global warming threat to ozone layer and the pollution of the oceans and seas reflect the growing physical and economic interdependence among nations on this planet. In fact it could be argued that environmental problems in most cases are of global nature in trumps of causes and effects.

Therefore, there is doubt that since the turn of the 20^{th}century human activities have resulted in detrimental changes in the soil, air, water, and land in the biological potential of terrestrial and aquatic ecosystems
(Hamid, 2000).

2.1.3.1. Environmental problems in developing countries

Developing counties are facing degradation not only in their fiscal, but also in their social environment. Physical environment degradation resulted from misuse of natural resources, which caused reduction in social environment quality. This in turn resulted in hunger, poverty, high mortality

and morbidity, sanitation problems and migration. Moreover, in these countries environmental problems and poverty are inseparable.

Most of developing countries are similar in social and political structures e.g. absence of public investment.

In 1987 many of the developing countries particularly in Africa were facing devastating drought and prolonged famine and declining stable food production. These conditions created the phenomenon of environmental refugees and provoked rural-urban migration. The major environmental problems of the Sudan are depletion and misuse of natural resources through overutilizing, overcultivation, overgrazing and deforestation, environmental refugees and wildlife destruction. (Bayoumi, 1984).

2.1.4 Factors affecting fishing harvest

2.1.4.1 Ecological factors

The chemistry of the water in the system is strongly influenced by flood cycle. During low water, conductivity and temperature rise slightly in the main channel and increase to a much greater degree in the standing waters of the flood pains. When water is spreading over the floodplain in the earlier stages of flooding, locally increased conductivities are found where salts are entering solution from the newly submerged soil.

Primary production is mainly concentrated in the higher vegetation, which grows rapidly during the floods to form extensive floating or routed meadows over the inundated areas.

A considerable amount of nutrients come from outside the aquatic system. In flooded forests the rain of organic detritus, insects, seeds, etc. is often the only source of food for creatures.

In general, the increase in the area of water during the floods releases nutrients from the terrestrial into the aquatic components of the system. This

results in a surge of production centered primarily on the growth of higher plants, which in turn support both epiphytic organisms and dense colonies of creatures in their root masses. (Wellcomme, 2003).

2.1.4.2 Mortality

Several causes of mortality can be identified but the various factors influencing total mortality including fishing tend to have similar timing. Most factors appear to be density-dependent. For this reason, mortality rates are thought to be low during the flood, rise to a maximum as the water leaves the plain and continues to be high during the rest of the low-water season. In general, it would seem that the population density is closely related to flood state. Total biomass increases throughout the wet season to a maximum towards the end of the flood phase. It then declines as the dry season progresses.

The production and biomass of fish in any river, therefore, fluctuate according to the flood regime. Heavy floods inundate larger areas, making available greater quantities of food, and improving conditions for reproduction and shelter. Recruitment, growth and survival are as a consequence better in years when discharges are high, subject to their timeliness, and the population is correspondingly greater. The natural year-to-year variation in flood intensity thereby produces a similar variation in the magnitude of the fish stock (Wellcomme, 2003).

2.1.4.3 Ecological factors of Jebal Aulia Reservoir

The water level of the reservoir begins to decrease in February, i.e. at the beginning of the second half of the dry season and this proceeds until April-May. By September the water reaches its highest level in the absolute mark of 377m.The annual amplitude of the water level in the reservoir is around 6m.

The reservoir is presently mainly being used for irrigation purposes. According to the Jebal Aulia Irrigation Department, which controls the dam, it is progressively being opened from middle of March to the first week of June (which also corresponds to onset of the rainy season in the Sudan). July-August is being used for maintenance work on the dam and re-filling starts the middle of August-September and by October the full capacity level is reached again. Although no particular attention is being paid by the irrigation department to any fishery activities during reservoir regulation, complaints are being voiced about the presence of fishermen too close to the dam and their nets hampering the proper operations of the evacuation canals.

It was reported that the fish ladder had not been operational since 1975 and that in1996, on special request of the research center, it is reopened in August-September of that year. During the initial re-opening, it was reported, both by the irrigation department staff and Jebal Aulia fisheries officers, that Iarge numbers of ***AIestes spp***. and even ***Labeo spp***. made use of the new route to gain access to the reservoir. This very interesting phenomenon must be taken into account when dealing both with fisheries management and stock assessment. The continuous presence of cast net fishermen on the fish ladder itself does not seem to be of an appropriate nature. (Bellmans, Marc (1997). The study attempts to show the effect of water level upstream Jebal Aulia and downstream the dam on the level of production.

2.1.5 other factors affecting fishing harvest

2.1.5.1 Collapse of fish stock

Typical explanations for the decline or collapse of fish stocks are that the fishery puts too much pressure on the stocks or that the environmental changes, affecting the productivity of the stock. In the management of

African freshwater fisheries, the traditional focus has been on fishing pressure with only limited considerations for environmental causes of changes in stocks. There is a long history of regulation against the allegedly detrimental effects of various fishing methods. Alert about the effects of ever-increasing fishing pressure are of a more recent date, and attempts to set sustainable levels of efforts have been the goal of much research. Although the various attempts to regulate fishing effort have often proved to be fairly ineffective. Many African fisheries continue to thrive. Changes in catch composition and of target species have often taken place, but few stocks have collapsed or declined severely (Clark 1990).

The wild harvest

Most fish production, some 83 percent, still comes from the wild harvest, and fishing remains the main expression of fish depletion.

From 1950-1990 the world's marine fish catch increased five fold, but since then the rate of growth has slowed, with an increase of 7 percent. Indeed estimates suggest that production from the capture fisheries has peaked and remained around the level 85-90 million tones a year. The increase was largely a result of the introduction of new technologies and spread of fishing from traditional areas to new ones, particularly in the southern hemisphere. Fishing fleets have grown at twice the rate of the increase in production and presently 3.5 million vessels seek out the wild stock. Overfishing is rife with too many vessels seeking out too few fish, often further and further away from their homeports.

FAO estimates that around 69 percent of stocks for which data are available are either fully to heavily exploited (44 percent), overexploited (16 percent), depleted (6 percent) (Professor Pinhciro, 1996).

2.1.5.2 Bycatch and discarding

It is defined as fish which are harvested in a fishery, but which are not sold or kept for personal use. Bycatch is unwanted catch. From this definition all retained catch would be considered targeted catch, while all discard catch would be considered by catch.

The significance of the apparent waste of fish arising from discarding has increased with the realization that the mortality of world fisheries are either fully or overexploited, FAO (1993) suggested that 13 of the 17 major global fisheries were depleted or are in serious decline. Although total of world production of fishery products continues to rise, reaching a peak of million tones in 1994, the proportion of wild fish landed for human consumption globally has decreased from around 70 million tones to 63 million tones between 1989 and 1993 (FAO 1996). With the difference being made up by increased landings of fish for reduction (i.e. non-human consumption and aquacultures.

The decline in landing of fish for human consumption and the realization that most world fisheries are overexploited has attracted the attention of humanitarian groups concerned with the welfare for developing countries. FAO has projected a growing gap between supply and demand for fisheries products as a result of population growth and decline in world fish stocks respectively. At the same time, large wastage of fishery resources are being observed from discarding unwanted catches at seas (Pascoe, 1997).

2.1.5.3 Beyond Capacity

Capacity of a vessel, or fleet, is its ability, or power, to generate fishing effort by period of time, in so doing some attempts are made to allow for the fact that a given fleet may operate in more than one fishery. Capacity has four components, these are:-

1. Number of vessels,

2. Size of each vessel,
3. Technical efficiency of vessel operation, and
4. Potential fishing time of each vessel.

In the great depression of 1930s, it was common for countries to attempt to alleviate their unemployment problem by manipulating tariff and exchange rates in order to reduce imports and increase exports. To the extent that these policies succeeded in a given country, it aggravated the unemployment problem in one or more of the country's trading partners.

Such policies came to be known as "beggar my neighbor" policies. We might term policies that reduce fleet capacity in fishery, hither to subject to overexploitation, but with consequence that fleet capacity is enhanced in other fisheries, also subject to overexploitation, as " beggar my neighbor is fisheries (Greboval, 1999)

2.1.5.5 Biodiversity loss

The main driving forces behind biodiversity loss stem is human activities that is for their economic utilization such as fishing, hunting may cause to the impact of an ecosystem (habitat destruction) while underlying causes include factors (economic, socio- political and degradation).

Despite the known facts about biodiversity loss, there is still a lot of scientific uncertainty about the response of freshwater ecosystems on biodiversity loss. Fish is many times chosen in the analysis of biodiversity loss in aquatic systems because of its attributes including ease of collecting information, high degree of speciation where different species reflect different environmental conditions. The study will try to see biodiversity loss in the aquatic life by analyzing loss of fish diversity in Sudan particularly in Jebal Aulia area Kasulo, (2000). The study tries to introduce

the surplus production model to estimate MSY and OE, also evaluate status in Jebal Aulia.

2.5. Management process

Fisheries management is a complex process that requires the integration of resource biology and ecology, with socio-economic and institutional factors affecting the behavior of fishers and policy makers. The purpose of this multidisciplinary field is to aid design making to achieve a sustainable development of the activity, so that future generations can also benefit from the resource. However, sustainability has been far more difficult to achieve that is commonly thought: fish populations are becoming increasingly limited, world catch has begun to drop, and almost 70% of the individual fish stocks around the world are fully to heavily exploited, overexploited or depleted. Indeed, depressed yields coupled with a rise in demand and prices, determined a systematic decreasing trend in catch rates and global landings. Conventional management measures, such as minimum size limits and reduction in catch or in fishing efforts, have been used to promote stock rebuilding by reducing fishing mortality and increase survival of spawning stocks (lansen, 2003).

2.5.1The classical approaches of fisheries management

Rational exploitation of fish stocks involves the control of fishing mortality (effort and fishing methods) in such a way that annual catches of specific stocks can be continued indefinitely according to pre-determined objectives related to the productivity at different stock levels. The catch effort curve of sustainable yields (Schaefer, 1954) exemplifies this approach: at any level of fishing effort up to the level where the surplus yield is maximized, a yield can be found that is theoretically sustainable and stable. Which level of fishing effort is chosen depends on a number of strategic objectives such as securing minimum biomass, maximizing food production (MSY), maximize the resource rent (maximum economic yield, MEY) or

employment. Of these objectives, the concept of maximum sustainable yield (MSY) at which effort level should be set in order to maximize food production has gained most prominence. Various models estimating MSY, or maximum yield per recruit, have been used extensively in African freshwater fisheries, and the concept of MSY has formed part of the research goals in many fisheries development projects as well (Synthesis report- Jul-Lansen, 2003).

2.5.3 Management policies in Malawi

Malawi implements three traditional fisheries management policies: gear restrictions, closed seasons and licensing. These policies are designed to protect against the decline in stocks below the MSY level. They are driven by a management goal maximizing sustainable yield not an economic one. Choice of the goal has implications for both biodiversity conservation and the efficiency of the fishery. Economic incentives can be used to compliment traditional policies in the conservation and sustainable utilization of fish diversity. Such incentives would involve changes in price of fish, discount rate and cost of effort. Sensitivity analysis of the optimal and open access solution to changes in the discount rate, cost of effort, and price can be used to demonstrate their effectiveness. The results of the sensitivity analysis for the demersal and gillnet fisheries, respectively show that each variable is changed while holding the other two constant.

It is clear that for the two fisheries under consideration, higher discount rates imply lower optimum values for both catch and effort.

A rise in the cost of effort increases the optimum level of fish stock and decreases the optimum level of fish catch and efforts. This is in agreement with the theoretical interpretation. It implies that rising costs lead to high levels of biodiversity since they reduce the harvest levels and raise

optimal stocks. Clark, (1990). The study tries to describe the traditional management policies and shows how Sudan could implement them and what the main constraints and implication to their implantation are.

Chapter Three

3. Socio-economic characteristics of fish production in Jebal Aulia Area:

This chapter provides data on the socio-economic characteristics and fish production as obtained from the analysis of collected primary data (questionnaire).

3.1 Socio-economic characteristics of fishermen

3.1.1 Age

Age has an important effect on productivity and output of individuals, either on the mental or the manual abilities. It can be recognize that from the table below that there is relatively high productivity due to the fact that younger fishermen prevail. This illustrates the importance of fishing as a job and indicates its attractive revenue, since younger people choose it as their main job. The age structure may prove that the fishing process is not easy and needs strength because when we move far from middle age the number of fishermen decreases.

Table (3.1): the Distribution of fishermen in terms of age.

Age class	Frequency	Percent%	Average product%
20-35	**9**	**17.0**	**50.0**
36-50	**25**	**43.7**	**30.0**
51-65	**18**	**25.0**	**15.0**
66-80	**8**	**15.3**	**5.0**
Total	**60**	**100.0**	**100.0**

Source: Sampling survey in 2004

3.1.2 Marital status

This reflects the family stability since it shows whether the fishing provides sufficient earnings that support the family, and satisfy its needs. The table shows that most of fishermen relatively very good standard of

living. Most of them have graduated sons and daughters (as they said) and 90% are married.

Table (3.2) marital status for fishermen

Variables	Frequency	Percent%
Single	**2**	**3.3**
Married	**54**	**90.0**
Divorced	**3**	**5.0**
Widow	**1**	**1.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

3.1.3 Education level:

Many researchers have explained the level of education and its relation with productivity and efficiency. Elementary education is common among fishermen. Production increases with the increase of education level.(recognized by the writer). Although one of the fishermen respondents is a graduate, but many of Jebal Aulia population are graduated fishermen.

Table (3.3) education level of fishermen

Variables	Frequency	Percent%
Illiterate	**10**	**16.7**
Traditional education	**8**	**13.3**
Elementary	**26**	**43.3**
Secondary	**15**	**25.0**
Graduate	**1**	**1.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

3.1.4 Main Occupation

This gives clear indication about of fishermen is satisfaction with their jobs and it supports them and implies a gain from it more than from other jobs. From the table the income of 81% of respondents is gained from

fishing. On the other hand, in addition to the main job, some have other jobs as mentioned below; the variety of jobs indicates that fishing is easy and available for each one.

Table (3.4) the main occupation of fishermen

Variables	Frequency	Percent%
Main job	**49**	**81.7**
Secondary Jobs	***11***	***18.3***
Total	***60***	***100***

Source: Sampling survey in 2004.

3.1.5 Job Season

From the table it is clear that most fishermen practice fishing all year round and that gives an indication of the strong reliance of fisherman on their jobs. 68% of respondents are present all year 15% in summer, 13% in winter and only 3.3% in autumn.

Table (3.5) the job season of fishermen

Variables	**Frequency**	**Percent%**
Winter	**8**	**13.3**
Summer	**9**	**15.0**
All year	**41**	**68.3**
Autumn	**2**	**3.4**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

3.1.6 Boats Ownership and distribution of fishermen per boat

3.1.6.1 Boats Ownership

Table (3.6) Boat ownership among fishermen

Variables	Frequency	Percent%
No	**31**	**51.7**
Yes	**29**	**48.3**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

There is a slight difference between those who own boats and those who do not. The first group represents 48% and the second 51% of the total number of respondents.

3.1.6.2 Distribution of fishermen per boat

The number of fishermen per boat ranges from 1-3 representing 35% and boats with 4-6 amounts to 13.3%. Note that boats with more than six fishermen do not exist. That is because they divide the income from the total production of the boat among themselves in a predetermined way. Therefore large numbers of fishermen per boat is not desirable.

Table (3.7) The number of fishermen per boat

Fishermen class	Frequency	Percent%
1 – 3	**21**	**35.0**
4 – 6	**8**	**13.3**
Response	**29**	**48.3**
No response	**31**	**51.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

3.1.7 Experience:

Table (3.8) the length fishermen's experience in years

Length	Frequency	Percent%
0 – 5	**4**	**6.7**
5 – 10	**5**	**8.3**
10 – 15	**9**	**15.0**
15 – 20	**12**	**20.0**
> 20	**30**	**50.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004

Half of respondents have an experience of more than 20 years, which indicates the long experience of fishermen, and their knowledge about location of higher rate of catch, the best time of fishing and how to use the suitable method of catch of the targeted species.

3.1.8 Society services

Table (3.9) Facilities that society provides

Services	Frequency	Percent%
Catch tools	**33**	**55.0**
Not provided	**24**	**40.0**
Not member	**3**	**5.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004

From the table above 55% of respondents received services from society, as catch tools 40% even not hear about it, 5% not joint the society, which has been established in 2002.

3.1.9. Reasons of migration to those who intend to migrate

3.1.9.1. Migration intention

Table (3.10) migration intention:

The answer	Frequency	Percent%
No	**9**	**15.0**
Yes	**51**	**85.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

From above 85% of respondents have the desire of migration to other locations or areas and 15% have not.

3.1.9.2. Reasons of migration:

Table (3.11) Causes of shifting to other locations

Variables	**Frequency**	**Percent%**
More number fishermen (over fishing)	**24**	**40.0**
Not profit	**1**	**1.7**
Low Product	**26**	**43.3**
Response	**51**	**85.0**
No response	**9**	**15.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

Those who migrated because of low production are 43% and others because of increased numbers of fishermen are 40%. Fishermen used to migrate seeking higher rate of catch along the reservoir.

3.1.10. **Best season for fishing:**

Table (3.12) the best season for fishing

Seasons	Frequency	Percent%
Winter	**11**	**18.3**
Summer	**26**	**43.3**
Autumn	**22**	**36.7**
All year	**1**	**1.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

From respondents best season for fishing is summer 43% then autumn 36.7% and winter 18% this is higher production in the mentioned seasons.

3.1.10.1 Best time of fishing:

Table (3.13) the best time for fishing

Fishing Time	Frequency	Percent%
Morning	**29**	**48.3**
Evening	**4**	**6.7**
Night	**21**	**35.0**
All day	**6**	**10.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004

The best time for fishing is early morning; which represents 48% then the night 35% all day 10% and evening 6,7%. They prefer early morning and night because of the quietness; and it is the suitable time for marketing. This is of especial importance since they have no insulated trucks to keep their production fresh till the time of marketing.

3.1.11 Fishing regulation

3.1.11.1 regulation Culture

Table (3.14) who knows the fishing regulations

Who know regulation	Frequency	Percent%
No	**3**	**5.0**
Yes	**57**	**95.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004

The fishermen who know the regulations of fishery are 95% and those who did not are 5%.

Job of regulation

Table (1.15) fishing regulations

What regulations do	Frequency	Percent%
Type of nets	**34**	**56.7**
Number of Fishermen	**8**	**13.3**
Number boats	**5**	**8.3**

Place of Fishing	**6**	**10**
All	**4**	**6.7**
Total of respondents	**57**	**95.0**
Said No	**3**	**5.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

According to fishermen answers fishing regulations determined the type of nets 34%, number of fishermen 8% location of catch 6% and number of boats 5%. From respondents the fish management is concentrated only on the type of nets according to legal mesh size and types of line used in catch; and neglect other important aspects of regulations.

3.3.2 Fishing tools and means of catch

Table (1.16) the tools and methods of catching

Methods			**Catch means**			**Type of nets according to eye size**		**Type of thread**			
	Freq	**Percent**		**Freq**	**Percent**		**Freq**	**Percent**	**Thread**	**Freq**	**Percent**	**Price of thread per kilo**
Traps	**28**	**46.7**	**Gillnet**	**10**	**16.7**	**Illegal**	**42**	**70.0**				
Cast net	**9**	**15.0**	**Long lines**	**4**	**6.7**							
Seines	**19**	**31.7**	**, Trammels**	**18**	**30.0**	**Legal**	**18**	**30.0**	**Mono-filament**	**42**	**70.0**	**70.000**
Long lines	**4**	**6.7**	**El mowshwisha**	**4**	**6.7**							
			trowels	**14**	**23.3**				**Nylon**	**18**	**30.0**	**40.000**
			Bee-bee(silka)	**10**	**16.7**	**Total**	**60**	**100.0**				
Total	**60**	**100.0**	**Total**	**60**	**100.0**				**Total**	**60**	**100.0**	

Source: Sampling survey in 2004.

From the table the methods used most frequently in fishing are fish traps, the seining, cast net and hand lines. The main instruments used for catching are Al silka, trowel seine, gillnet, Alfa, and Almowshwisha. The types of nets are divided into legal and illegal according to the size of eye and mesh size. If it is less than the standard, which included in fish

regulation then it is illegal and vise versa. The prevailing types of nets are the illegal ones, which amount to 42%.

It can be observed that although Asab (mono-filament) line is more expensive than nylon line, most of fishermen prefer to buy it because it is lighter in weight, (so they can buy big amount) when compeers to nylon and Asab line is distinguished by higher catch. Using Asab line is illegal for the depletion of fish it causes. (Asab line cannot be seen under water).

3.1.13 Type of boats

Table (1.17) the types of boats

Boats type	Frequency	Percent%
Sonot(wood)	**18**	**30.0**
Ion (metal)	**19**	**31.7**
Other	**5**	**8.3**
Total	**42**	**70.0**
Have not	**18**	**30.0**
	60	**100.0**

Source: Sampling survey in 2004

In past years wood boats were common but shown in the table the use of iron boats are increasing rapidly because fishermen discovered that iron boat is the best.

3.4. Fish production

There are many indicators, which could be used to measure the change in productivity. Among these; change in fish structure, and change in fish size and quantity of production are of top importance.

All respondents confirm the change in species, and decrease in structure.

3.4.1 Change in fish structure

The change in fish structure affects all species especially ***Citharinus citharus*** and ***Protopterus senegalus*** , for these the decrease is 100% in addition to commercial fish which is about 50% (***Bagrus bayad., Telapia zilli. ,Bargus Docmac, Alestes dentex., Hydrocyonus forkhali., Clarias lazera, Synodotis sp., spand Mormyrus caschive.).***

3.4.2 The reasons behind the change of fish structure

Table (3.18) the reasons behind the decrease of fish structure

Change reasons	Frequency	Percent%
Overfishing	**47**	**78.3**
Environmental Factors	**12**	**20.0**
Pollution	**1**	**1.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

According to the respondents the reason behind change in fish structure is overfishing or overexploitation of fishery resources, then environmental factors such as (storm, water level, temperature, and rain fall). Although only one respondent regards water pollution as the cause behind the change in fish structure still research proved the relation between water pollution and fish structure.

3.4.3 Favorite Fishes:

Table (3.19) the favorite species for fishermen to catch

Favorite species for catch	Frequency	Percent%
Oreochromis niloticus	**9**	**15.0**
Bagrus bayad	**5**	**8.3**
Barbus bynnie	**6**	**10.0**
All the above	**40**	**66.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

From table (3.19) the fishermen prefer to catch the demanded types of fish by consumers. That is because they are easily marketable with better returns.

3.4.3 The change in fish size

All respondents agree that the small size of all type of species is decreasing over time.

3.4.4 The season during which fish size change:

Table (3.20) the seasons in which species become small

Seasons of small size	Frequency	Percent
Winter	**48**	**80.0**
Summer	**4**	**6.7**
All year	**3**	**5.0**
Autumn	**5**	**8.3**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

Most of respondents noticed that the size of all types of fish is smallest in winter compared to other seasons.

3.4.5 The change of quantity of production:

All respondents confirmed that the low rate of production is inclusive and does not exclusive to a certain specific type.

Reduction in production occurs to all species especially ***Alestes dentex Hydrocyonus forkhali, and Labeo niloticus*** in adition to ***Barbus bynnie, Telapia zilli. and Bargus bayad.*** We recognized that the species mentioned are all demanded as a commodity for the market and not a produce for personal consumption.

3.4.6 Seasonality of production

Table (3.21) the seasons in which fishes increase or decrease

Seasons	Winter	Summer	Autumn
Increase%	**15.0**	**56.7**	**60.0**
Decrease%	**81.7**	**10.0**	**13.3**
Total (increase, decrease)%	**96.7**	**66.7**	**73.3**

Source: Sampling survey in 2004.

In normal conditions the quantity of produce decreases during the period between July – October, because of the following reasons:

- Water pollution (this is the period in which sugar industry projects have the highest discharge of excess water- rainy seasons).

- ❖ The increase of Nile water level (the increase in water level makes catching fish difficult for the fishermen).
- ❖ The increase of rainfall rate (as a logical consequence in water level).

3.4.6.1 The reasons behind the decrease of quantity of Production

Table (3.22) the reasons of the reduce amount of fish production.

Reasons of decrease	Frequency	Percent
Over fishing	**50**	**83.3**
Pollution	**1**	**1.7**
Environmental Changes	**9**	**15.0**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

Most of the fishermen agree that the main reason behind the reduction of the quantity per catch is the increase in the number of fishermen in the area.

3.5. Fish marketing

3.5.1 Marketing status

Table (3.23) the fish treatment when marketed.

Fishes marketing	Frequency	Percent%
Fresh	**58**	**96.7**
Salted	**1**	**1.7**
All	**1**	**1.7**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

It was recognized that most quantities of fish were sold fresh to Wholesale fish merchants, who either sells them;

a) In the main markets,

b) Local markets or

c) Household consumption or its processing into conserved food.

The prevailing marketing system is that whole sale merchants come to the area of production (Jebal Aulia reservoir).

3.5.3 Fish transportation:

Table (3.24) the means of transportation of fish

Fish transportation	Frequency	Percent
Insulated trucks	**12**	**20.0**
Non insulated trucks	**15**	**25.0**
Animals	**13**	**21.7**
Carrying on foot	**20**	**33.3**
Total	**60**	**100.0**

Source: Sampling survey in 2004.

From table (3.24) the quantities transported carrying on foot is more than other types of transportation, which proves that it is easier. This is limited to the quantity marketed in local market or near the area of the Dam.

3.5.4 Type of market

Table (3.25) the type of markets

Fish markets	Frequency	Percent
Main market	**9**	15.0
Local market	**51**	85.0
Total	**60**	100.0

Source: Sampling survey in 2004.

3.5.5 Average production per boat

Table (3.26) the average quantities of production in kgs.

Production Mean	**20.383**
Minimum	**2.0**
Maximum	**50.0**

Source: Sampling survey in 2004.

The average quantities produced are 20.383 kg per boat, and then this is distributed between the boat owner and the hired fishermen in away they agree to.

3.5.6 Average income per capita per day

Table (3.27) fishermen average income

Income Mean	**35025.00**
Minimum	**2500**
Maximum	**150000**

Source: Sampling survey in 2004.

The average of fisherman income 35025 S.P (Sudanese pound) daily, which is, seems to be under stated very much.

Chapter Four

Analysis, Findings and Results

4.1 Analytical techniques

Simple data for analysis were used, since there was not sufficient and reliable data for more than five years. Most of the available documents and reports of a general nature and statistics about Jebal Aulia were scarce. Researcher depended on few data for descriptive statistics and other techniques.

4.1.1 Correlation and pictorial presentation

To test the relationship between effects of water level on fish production over five yeas, the coefficient of correlation was calculated using the SPSS program. Also pictorial presentation was utilized making use of EXCEL program. It is worth mentioning that the data were of two types: upstream and downstream Jebal Aulia Dam.

4.1.2.Trend and correlation analysis

The correlation analysis was used to estimate the degree of relation-ship between production as a main factor, and the number of boats, the

number of fishermen and per unit catch effort as independent factors. The trend analysis was executed also to show the trend of

a) The total fish production over five years,

b) The CPUE over the same time. For this purpose the equation below was used;

$Y=a_0+a_1x_1+a_2 x_2+a_3x_3$

Where: a_0, a_1,a_2…etc are coefficients

Y is yield

X_1 represents 1998

X_2 represents 1999

X_3 represents 2000

X4 represents 2001

X_5 represents 2002

4.1.3.**Surplus production model**

The model used EXCEL programming package to estimate the maximum sustainable yield (MSY) the level at which stock is safety. And the optimal effort (OE) is the optimal number of boats by which MSY could be achieved. To decide if there is depletion or not the optimal estimated values were compared to the actual one. If the calculated MSY is less than the actual yield i.e the catch exceeds the sustainable level then there is depletion and the stock is in danger, and vice versa. The model contents are as follows

Total Production = CPUE*EFFORT

a) CPUE = catch per unit effort (catch per boat)

Total production / number of boats in the same year.

b) EFFORT= number of boats * fishing days

= Number of boats * 365

c) MSY =maximum sustainable yield

MSY=-a2/4b

d) OE=optimal effort.

OE=-a /2b

Where: a= intercept

b= slope in c) and d)

When we compare efforts with CPUE data vis table (4.1).

Table (4.1) factors that affect the fish production

Years	Total production	Number of boats	Effort	CPUE
1998	**672840**	**252**	**91980**	**7.3**
1999	**551335**	**201**	**73365**	**7.5**
2000	**526666**	**151**	**55266**	**9.5**
2001	**529503**	**123**	**44895**	**11.7**
2002	**517416**	**110**	**40150**	**12.9**
TOTAL	**2797760**	**837**	**305656**	**48.9**

Source: Department of fisheries, 2005

4.2. **Results**:

The following are the main parameter to measure fish depletion in Jebal Aulia area; a) the change in fish structure b) decrease in fish size c) low production. Each one of these indicators will be discussed separately.

4.2.1. **Change in fish structure**:

All respondents confirmed that, fish structure changed over time. There was a reduction in some of the fish species while other species became very rare, namely (***Protopterus senegalus. and Citharinus citharus***). For example (***Protopterus senegalus***) appeared rarely while ***Citharinus citharus*** did not appear for the last six years. Table (4.2) confirms the above result. The high rate of change of the targeted species (***Barbus bynnie, Telapia zilli, Bagrus bayad, Alestes dentex and hydrocyonus forkhali)*** could be easily detected and observed

Table (4.2) the percentage change of fish structure according to respondents answer.

Species	***More increase***	***%More decrease***	***No answer***	***Total***	***Local names***
lates sp.	***0***	***65***	***35***	***100***	***Egel***
Tilapia sp.	***0***	***50***	***50***	***100***	***Bulty***
Bargus sp.	***0***	***55***	***45***	***100***	***Bayad***
Clarias sp.	***0***	***41***	***59***	***100***	***Grmot***
Synodotis sp	***0***	***50***	***50***	***100***	***Grgor***
Protopterus sp	***0***	***100***	***0***	***100***	***Umkoro***
Labea sp	***0***	***45***	***55***	***100***	***Dabis***
Citharinus sp	***0***	***100***	***0***	***100***	***Bitkwia***
Alestes sp	***0***	***60***	***40***	***100***	***Kwara***
Hydrocyonus sp	***0***	***45***	***55***	***100***	***Cas***
Mormy sp	***0***	***35***	***65***	***100***	***Khashmbanat***

Source: sample survey 2004.

That agreed with the results of Hamid, (2000) when compared five areas in the table below to show the most affected one by the industrial waste water of sugar projects in white Nile. she stated*: **"generally as we move north (from Gazira Musran for instance to Jebal Aulia) the negative effect of water pollution on fish species decreases, and the increase in consumption becomes the most important cause of change"*** .vis table (4-2) therefore the main reason behind the change of fish diversity could possible be overfishing.

Table (4.2) change in fish structure using t-test analysis.

Fishing area	**t. Calculated**	**t. Tabulated at 5% level of significance**
Gizira Musran and Gazira Aba	**4.30**	**2.09 ***
Gazira Musran and el Shawal	**4.20**	**2.09 ***
Gazira Musran and el Kunuz	**1.63**	**2.09**
Gazira Musran and Jebal Aulia	**3.39**	**2.09 ***

Source: Hamid (2000) thesis under the title environmental impacts of sugar industry wastewater on White Nile area. (Page 46)

If t calculated > t-tabulated (t calculated = 3.04) then the deference is significant at 5% level of significance

4.2.1.2 **Decrease in fish size (length)**:

All respondents confirm the decrease of all mentioned species, viz table (4.3) compared the legal standard length, with the actual length taken during the survey. There was a big difference between the legal (the length that determined in regulation low document) and actual length.

Table (4.3) the actual and illegal length of some species.

Targeted species	**The legal length of targeted species (cm)**	**Average actual length of targeted species (cm)**
Barbus bynnie	**45**	**19-72**
Bagrus bayad	**55**	**31-70**
Telapi zilli	**20**	**8-34**
Labeo niloticus	**45**	**17-59**
Hydrocyonus orkhali	**30**	**20-10**
Alestes dentex.	**20**	**10-15**

Source: Regulation office in Jebal Aulia and sample survey 2004.

Concerning the reasons that cause the decrease in fish sizes Hamid (2000) mentioned in her study **" *the main reason for the decrease in fish size***

in Jebal Aulia area is the increase in consumption, followed by change in habitats and water pollution." Vis table (4.4)

Table (4.4) the percentage cause of decrease in fish size.

Location	**G. Musran**		**G.Aba**		**Shawal**		**Kunuz**		**J.Aulia**	
Reasons	**frequency**	**%**	**frequency**	**%**	**frequency**	**%**	**frequency**	**%**	**frequency**	**%**
Increase in consumption	**19**	**70.4**	**22**	**37.3**	**20**	**35.1**	**20**	**52.6**	**14**	**58**
Water pollution	**2**	**7.4**	**26**	**44.1**	**23**	**40.3**	**8**	**21.1**	**2**	**8.3**
Change in habitat	**6**	**22.2**	**11**	**18.6**	**14**	**24.6**	**10**	**26.3**	**8**	**33.4**
Total	**27**	**100**	**59**	**100**	**57**	**100**	**38**	**100**	**24**	**100**

Source: thesis by Hamid, (2000) Environmental Impacts of Sugar Industry Waste Water on White Nile Area.(page 48)

Table (4.5) the result of the decrease in fish size.

Location	**Affected areas**	
Reasons	**Frequency**	**%**
Increasein consumption	**76**	**42**
Water pollution	**59**	**33.1**
Change in habitat	**43**	**24.2**
Total	**178**	**100**

Source: thesis by Hamis (2000). Environmental Impacts of Sugar Industry Waste Water on White Nile Area.(page 48)

4.2.4. The effect of water level in production.

Table (4.6) average Monthly White Nile water level of upstream Jebal Aulia Dam in meters).

	1998	**1999**	**2000**	**2001**	**2002**

Jan	**377.3**	**377.3**	**377.3**	**377.1**	**354.5**
Feb	**377.3**	**377.3**	**377.1**	**376.7**	**377.1**
Mar	**377.0**	**377.1**	**376.6**	**376.4**	**367.6**
Apr	**376.2**	**375.9**	**375.0**	**375.5**	**375.4**
May	**374.2**	**374.0**	**373.4**	**373.6**	**373.3**
Jan	**373.8**	**372.9**	**373.2**	**373.3**	**372.7**
Jul	**374.5**	**374.8**	**375.1**	**374.9**	**374.8**
Aug	**376.6**	**376.5**	**376.9**	**376.9**	**376.8**
Sep	**377.3**	**377.0**	**377.3**	**377.3**	**377.2**
Oct	**377.4**	**377.5**	**377.3**	**377.3**	**377.5**
Nov	**377.4**	**377.3**	**377.3**	**377.3**	**377.5**
Dec	**377.2**	**377.2**	**377.2**	**377.2**	**377.4**

Source: Ministry of Irrigation and Water Resources

Nile Water Directorate.

Table (4.7) average Monthly White Nile water level of Downstream Jebal Aulia Dam in meters).

	1998	**1999**	**2000**	**2001**	**2002**
Jan	**372.4**	**372.5**	**372.5**	**372.5**	**372.5**
Feb	**372.3**	**372.4**	**372.4**	**372.3**	**372.4**
Mar	**372.4**	**372.1**	**372.5**	**372.2**	**372.4**
Apr	**373.0**	**372.6**	**372.7**	**372.3**	**372.5**
May	**372.4**	**372.3**	**372.1**	**372.2**	**372.3**
Jan	**372.0**	**372.3**	**372.0**	**372.0**	**371.9**
Jul	**372.8**	**372.6**	**372.2**	**372.5**	**371.6**
Aug	**375.8**	**375.6**	**375.2**	**376.0**	**374.7**
Sep	**376.2**	**375.1**	**374.6**	**375.1**	**373.2**
Oct	**374.6**	**374.7**	**373.7**	**373.0**	**372.7**
Nov	**373.6**	**373.4**	**373.0**	**373.0**	**372.5**

Dec	**372.7**	**372.7**	**372.5**	**372.6**	**372.4**

Source: Ministry of Irrigation and Water Resources

Nile Water Directorate.

The data cited above is used to investigate the effect of change in water level on production. Using SPSS programme, and the results as shown below:

Correlations: table (4.8) degree of correlation between water level and fish production.

		Water level	Production
Water level	**Pearson's correlation**	**1.000**	**.435**
	Sig. (2-tailed)	**.**	**.464**
	N	**5**	**5**
Production	**Person Correlation**	**.435**	**1.000**
	Sig. (2-tailed)	**.464**	**.**
	N	**5**	**5**

Table (4.9) Descriptive Statistics

	Mean	Std. Deviation	N
Water level (meter)	**373.660**	**4.043**	**5**
Production (kg)	**559552.00**	**64539.84**	**5**

Table (4.8) show that the relation between production and water level as a habitat change is not significant. From the table .435<. 464 that mean the low rate of production is not caused by the change in water level. also the standard deviation is quite big, which reflects the big difference between the max and min value of production.

From table (4.9) the std. Deviation is nearly small and that describe the steady state of water level. Figure (1) shows that while the production rate is decreasing the water level is also decreasing during the same years. From figure (1) at first the water level began to decrease in semi stable manners and then has sharply decreased. The opposite case for production, which at first sharply decreased then has slightly decreased, which is explains that the water level was not the main reasons of low rate of production.

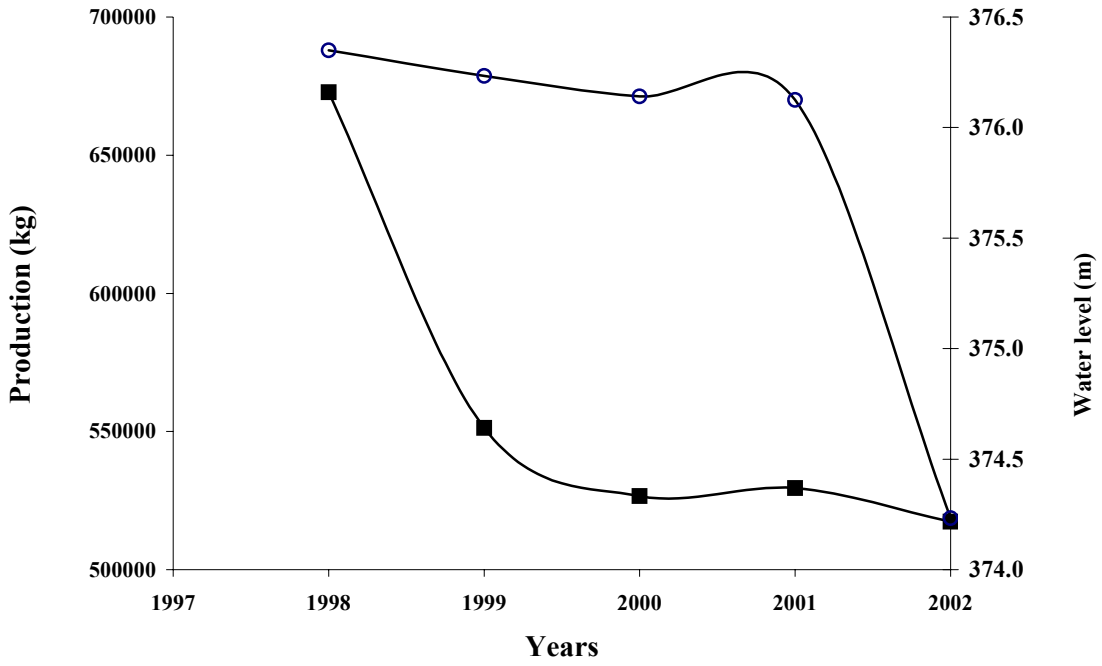

Fig. 1: Effect of water level on fish production in upstream Jebal Aulia Dam

Source: Ministry of Irrigation and Water Resources

fig (1) shows the relation between production and water level upstream Jebal Aulia Dam.

- Water level
- The production curve

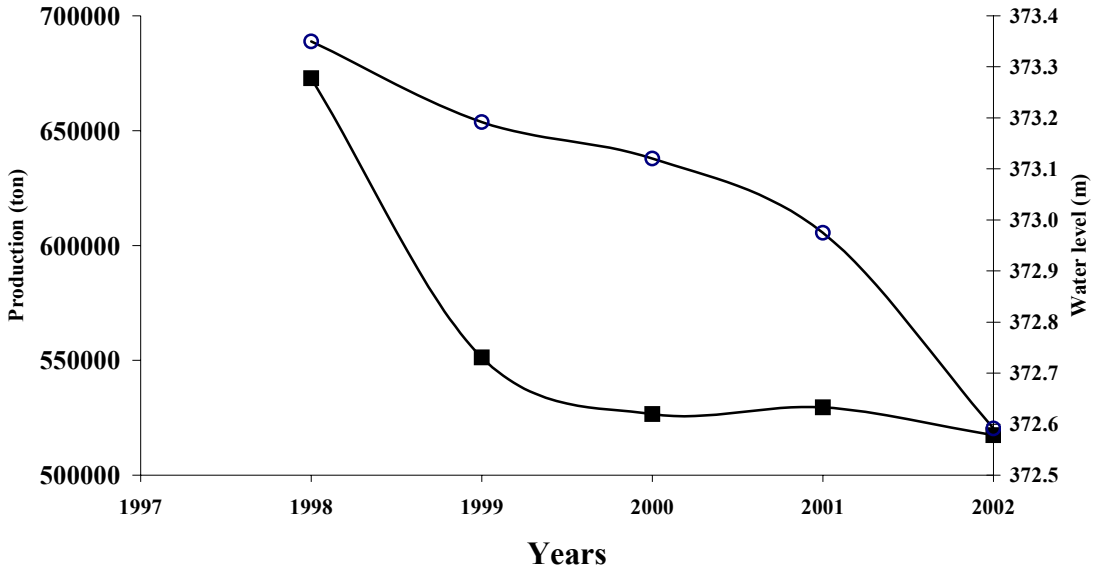

Fig. 2: Effect of water level on fish production in down stream Jebal Aulia Dam

Source: Ministry of Irrigation and Water

fig (2) show the same result for the analysis between production and water level downstream Jebal Aulia.

- Water level
- The production curve

4.2.2. **The low level of fish production:**

All respondents confirmed the decrease in the rate of fish production and change in fish structure over years. The correlation analysis results between the dependent variable (production) and the independent variables (number of boats, efforts and CPUE) is explained in table (4.10) The relation between production and number of boats is found to be significant and positive. Also the relationship between production and effort is significantly positive at 5% level of significance. But the relationship between production and CPUE was negative. In other words as the number of effort and boats

decrease the production level decreases also, while the CPUE (catch per boat) increases. Although this seemed to be clear, however the rate of the decrease in production was less than the rate of decrease in number of boats and in effort. That might be due to the increase of CPUE as demonstrated in fig (3) and, Figure (4), which, reflected the trend of fish production and CPUE respectively, and explain the opposite relationship.

Correlation: table (4.10) correlation results between production and other factors.

		Production	Number of boats	Effort	CPUE
Production	**Pearson Correlation**	**1.000**	**.896**	**.896**	**-.687**
	Sig. (2-tailed)	**.**	**.040**	**.040**	**.200**
	N	**5**	**5**	**5**	**5**
N/boats	**Pearson Correlation**	**.896**	**1.000**	**1.000**	**-.932**
	Sig. (2-tailed)	**.040**	**.**	**.000**	**.021**
	N	**5**	**5**	**5**	**5**
Effort	**Pearson Correlation**	**.896**	**1.000**	**1.000**	**-.933**
	Sig. (2-tailed)	**.040**	**.000**	**.**	**.021**
	N	**5**	**5**	**5**	**5**
Cpue	**Pearson Correlation**	**-.687**	**-.932**	**-.933**	**1.000**
	Sig. (2-tailed)	**.200**	**.021**	**.021**	**.**
	N	**5**	**5**	**5**	**5**

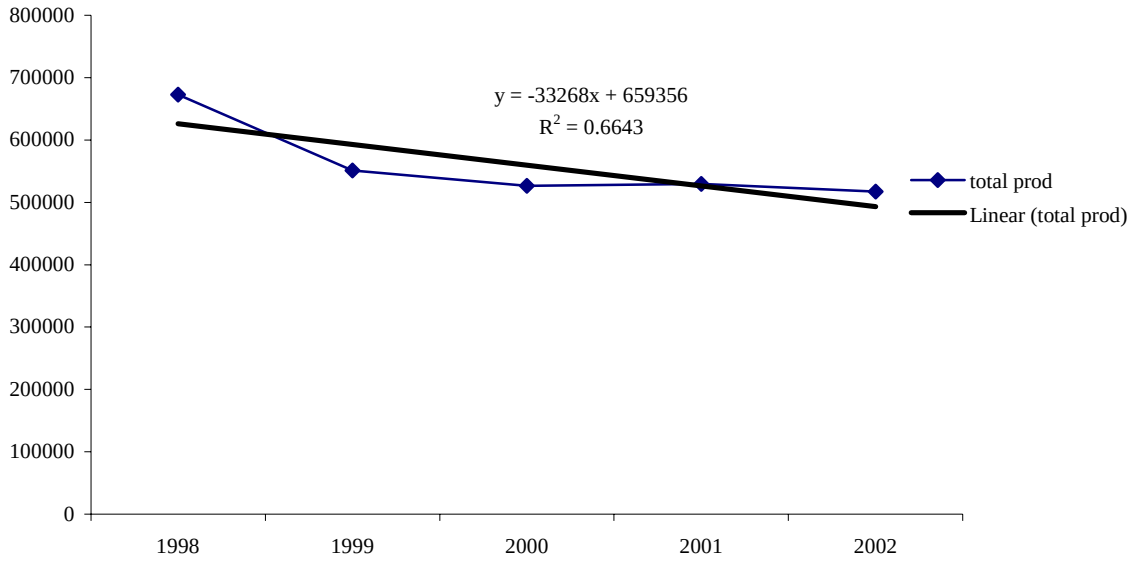

fig 3 the Trend Analysis of Fish Production

Source: Ministry of Agriculture and Animal Wealth and water resource Khartoum

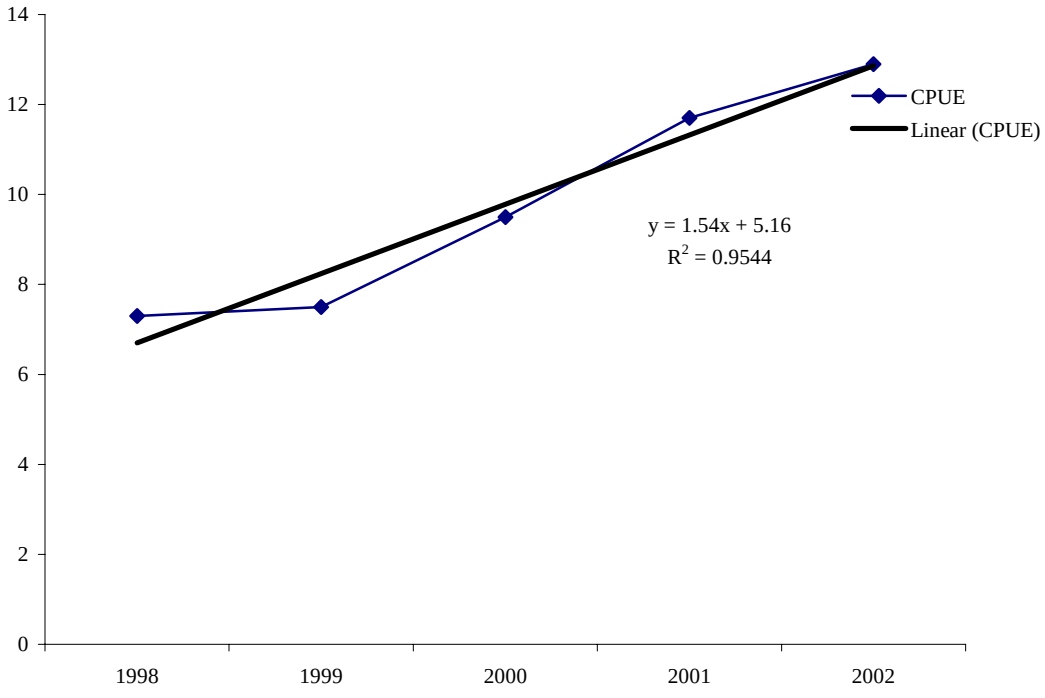

fig 4 the Trend Analysis of Fish CPUE

Source: Ministry of Agriculture Animal Wealthand water resource-Khartoum

The estimates of MSY and OE

Table (4.11) total production and factors affected it over time.

Years	Total product	Number of boats	Effort	CPUE
1998	672840	252	91980	7.3
1999	551335	201	73365	7.5
2000	526666	151	55266	9.5
2001	529503	123	44895	11.7
2002	517416	110	40150	12.9
TOTAL	2797760	837	305656	48.9

Source: Ministry of Animals and Fisheries Resource.

data From table (4.11) were used , to estimate MSY and OE using EXCEL programme. using the formula:

MSY=-a2/4b

OE=optimal effort.

OE=-a /2b the result show that

a=16.40611

b =-.000108

MSY =623056.57

OE= 75954.2

From the table above the MSY result is 623056.57 kg,(EXCEL programme) and that is the level at which the stock is safety, in other words this is the optimal value of catch in the five years. When this value with the actual catch (2797760) kg that indicates the problem of high depletion because the actual value is more than the optimal value in Jebal Aulia Area. Also the optimal efforts (boat/ days), (75954.2) the optimal number of boats to attain the MSY level exceeded the optimal value.

MSY =623056.57< 2797760 actual catch of the area.

The OE: Optimal Efforts

OE= 75954.2< 305656

This proves that there is great depletion due to overfishing in Jebal Aulia area. This fish depletion requires intervention and development of new polices and regulation.

4.2.6. **Management policies:**

Since the government of Sudan is recently paying considerable attention to the questions of food security and alleviation of poverty, then it is expected to design policies suiting these goals:-

1. Maximize the safe sustainable yield from fish stocks that can economically be exploited from the national waters.
2. Improve the efficiency of exploitation, processing and marketing;
3. Exploit all opportunities to expand existing one and develop new aquatic resources.

First regulation and control of fisheries is the responsibility of the Department of Fisheries of the Ministry of Agriculture and Animal Resources.

These policies include the following: -

4.2.6.1 **Licensing:**

The basic idea of a licensing scheme is to restrict the number of participants to a fishery such that they exert the desired amount of fishing. Several issues are important. Exactly what should be licensed? The fisherman?, the boat, or the unit of gear? Also what is the rate at which the optimal number of licenses to be targeted?.

For reasons of economic efficiency, it is usually best to license the vessel. It is useful to point out, however, that while licensing the boat is usually superior there may be special cases where another item is more appropriate.

Types of fishing licenses, which may be issued, included, commercial fishing licenses, fishing vehicle licenses, trout fishing licenses and trade fishing licenses. Recreational fishing by rod or hand line and private fishing by hand net do not require licenses. There is a provision to limit the number of fishing licenses for any class of fish .The intention behind this provision is to ensure that where fish resources are threatened by too many fishermen, the Department of Fisheries should be able to avoid depletion of fish stocks by limiting the number of licenses. This should be followed by strict monitoring to see the respect and execution of regulations.

4.2.6.2 Gears restriction

Gears restriction means to control all instruments that are used for fishing e.g. certain methods of fishing. These include use of certain nets (including mesh size). Table (4.12) shows that it is clear that the percentage of illegal means, nets, and thread used for catching fish is very high.

Table (4.12) the percentage of illegal practices of fishing in Jebal Aulia area.

The percentage	Catch means	Types of nets (mesh size)	Type of thread
Legal	**18**	**18**	**18**
illegal	**42**	**42**	**42**
Total	**60**	**60**	**60**

Source: sample survey 2004

The restrictions include the tools of catch (BeeBee net Silka and Alfa …etc) and the type of thread used for catching (monofilament).

4.2.6.3 Closed seasons

This is to prohibit fishing during certain specific periods. It may apply in general or with respect to a particular area of the White Nile. This ensures

that fish can breed during that period and that fishermen do not catch young fish.

4.2.6.4 The common property status of fishery resources

Common property resource refers to resource held or used by all who choose to do so. The term is often used synonymously with " open access resources". A resource is common property when it is not or cannot be owned or used by an individual or individual-like entity to the exclusion of others.

Because fish stocks are common property, the activities of any one fisherman affects the catches of all others exploiting the same stock. One result of this is that the catches taken by a new boat added to a fishery are not a good measure of the benefits, to the fishery as a whole, produced by that additional boat. Unless the stocks are lightly fished, the net additions to the total catch will be less than the catch by the additional boat, the difference being the deduction in the catch by the existing boats.

Resolution of the open-access problem has become more urgent because of increased fishing pressured on a worldwide scale. The growing demand for fish, through increased population, and higher personal incomes in many countries, has raised the world fishing exploited.

For example, reducing the incentive through the imposition of taxes or royalties may control the entry into fishery. The case of Jebal Aulia area is semi open access because of the regulation absence.

Chapter Five

5. **Summary, Discussion, conclusions, and Recommendations**

5.1. **Summary:**

The study regards biodiversity as a hot issue that concerns food security worldwide. The study emphasizes the losses of biodiversity in general and especially fish diversity in White Nile, Jebal Aulia area. It pointed out that overfishing practice led to the loss of fish diversity, which has many indicators; such as: low production, change in fish structure and decrease in fish size. In addition, illegal human activities and practices, explain the absence of fishing regulations and legislation.

The study area included data of up and downstream of Jebal Aulia Dam. The study reviewed the literature on fish diversity at both levels globally and locally. The literature review proved beyond doubt the importance of fish as a source of food. Basic environmental concepts such as externality and open access were introduced and defined. The factors that cause the loss of fish diversity were discussed with the aim to identify the causes and hence the remedy. The question why the regulations and management polices were not implemented was found to be because of poverty of most of fishermen. Overfishing has negative effect on aquatic life such as the direct overexploitation of species, ecosystem degradation, which leads to species loss, habitat destruction and conversion. Catching fishes before maturity leads to short life span and adds to fish's mortality rate.

The problem of loss of fish diversity reflected in low production, change of fish structure and decrease in fish size in Jebal Aulia area. The results show that besides the three causes of loss of fish diversity (water

pollution, change in habitat and overfishing) over- fishing was the main reason for fish depletion.

The study introduced a description of the policies meant to resolve the problem of overfishing through the following approaches e.g controlling of license, prohibition of illegal gears and closed season. Full dependency of fishermen on fishing as their sole income-generating activity and their wide spreading along the river banks makes it difficult for them to abide by rules and regulations.

5.2. **Discussion:**

The main emphasis of this study is to investigate the fish situation with regard to depletion and restocking in Jebal Aulia. To measure the status the following indicators (fish production, fish depletion and fish size) have been used. The study also shows the main constraints of fishery regulation, and describes policies imposed to control overexploitation and prevent the open access procedures.

5.2.1The decrease of fish production as an indicator of fish depletion

Results show the positive relation between the production as an independent factor, and the other dependent factors (number of boats, efforts and per unit catch effort). The rate of production decreases over time especially in the last five years. Though the number of boats also decreased during the same period, but due to the significant increase of CPUE the decrease in the total production could be regarded as negligible. This indicates that the actual production of fish exceeds the MSY and thus results in fish depletion in the area.

Low level of production may occur due to one of the following three reasons:

1. Water pollution,

2. Change of habitat, and
3. Overfishing

A Study conducted by Hamid, (2000) in the same area confirms that the main reason of low level of production is the high consumption in response to high demand. Which means that the high rate of fishing to supply the increasing market demand; especially to locations around the Capital with high population density and relatively high-income level.

The effect of water level on fish production was analyzed by using correlation. Insignificant results were obtained and illustrated that; water level had no effect or little effect on fish production. By comparing the monthly averages of water level up and downstream it can be recognized that there was steady state of water level.

Figure (1) and (2) support the result (the linear curve between production levels and average water level) in the same years.

The surplus production model shows that the actual production of Jebal Aulia was highly exploited over the optimal sustainable yield. The actual efforts are also over the optimal efforts, and that high level of production and increased number of boats resulted from overfishing and open access fisheries.

5.2.2 The changes in fish structure:

According to respondents answers there has been clear change in fish structure; especially in ***protopterus senegalus and Citharinus scitharus*** species. A number of fish species became rare and appeared from time to time. ***Protopterus senegalus***. And some species have never been seen for the previous six years. These findings agreed with the result of Hamid, (2000). Thus the main reason behind the change of fish diversity is overfishing.

5.2.3 The decrease in fish size

Jebal Aulia population depends too much on fishing; thereby it is their direct way of income. The long experience of fishermen led them to make their nets locally according to mesh size they need for illegal practice not as standered. From table (4.12) it could be observed that there is high rate of illegal net, also from table (1.6) shows the small size of mesh size (less than 2 cm) when fishing is for house to make up other types of food.

Table (4.3) reflects the big difference of the actual length from the survey and the legal length for example (***Barbus bynnie*** is 19 cm, ***Hydrocyonus forkhali*** is 10 cm and ***alestes dentex*** is 10 cm).

The study by Hamid, in the same area revealed that increase in consumption played a major role in decreasing the size of fish. Increasing consumption is another reason of overfishing. Then the small size of fish is one main indicator for the loss of fish diversity in Jebal Aulia area.

5.3. **The main policies of fish regulation**

Implementing the regulations and policies of licensing, gears restriction and closed seasons is not an easy task. This requires well-trained staff and adequate funds. But when a resource is depleting then it is a must to apply regulations and policies. It is recognized that local knowledge and skills can enhance conservation and management of fisheries and reduce pressure on enforcement. To this end efforts are underway to come up with a new. Fisheries Conservation and Management. Act, which would include the involvement of local communities in the management of fish resources. Walker, (1976).

5.3.1 **Constraints to implementing fishing regulation policies.**

The Fisheries Department, as a government institution, has the mandate to issue fishing licenses for the purpose of controlling effort. This goal has not been achieved, especially among the traditional fishermen, as

they are widely spread all over the river. This makes it impossible to cover the whole area by license monitoring teams, who also happen to be part of the enforcement team.

The policies that, encouraged focusing more on fishermen, may increase the level of effort (number of fishermen per boat) which has driven profits down to almost zero, thereby reducing the income of existing fishing communities. This situation has been worsened by lack of alternative income-generating activities. Fishermen are locked into a short-run survival strategy whereby they are unable to curtail effort in order to conserve stocks or increase economic efficiency, for this would mean going without food.

Poor enforcement of fisheries regulations reflects lack of effective institutional structure to carry out this task. Also the enforcement section of the Fisheries Department has insufficient manpower and equipment. It also receives little support from other related institutions (police and judiciary). (Bland and Donda, 1994).

The fishing regulation document neglects other important aspects; such as: the border of fishing location, the space between nets in the river and the number of those who practice fishing as a hobby and for recreation purposes.

5.4. Conclusion:

It could be stated that overfishing is the main proximate cause behind fish diversity loss in the White Nile, Jebal Aulia area. Overfishing resulted in the extinction of some species, (depend on primary data) reduction in production and reducing size of fish species. The factors that cause over-fishing include property rights and weak institutional structure.

5.5 **Recommendations:**

1. Fisheries should be rationally managed and the different aspects of its management should be thoroughly studied. Fishermen should be considered as the sole and main target of the recommended studies.
2. Fishermen should be advised to organize themselves in societies that would work for the following purposes:-
   a) to avail and provide fishermen with needed tools,.
   b) To promote the marketing mechanism in such a way to maximize their
      revenues,
   c) To suggest and execute productive projects, for instance, developing fishing methods and expand the fishing industry, so that a fisherman can find alternative opportunities for income generating hopefully this might substitute for over- fishing.
3. Regulation office of fisheries department should cater for the control of the optimum number of fishing boats and the legal fishing tools and limiting fishing to the assigned areas so as to allow for fish reproduction and restocking.
4. Fishing regulations should be revised every now and then to cope with the changing fishing status. At the same time care should be given to awareness raising an advocacy for the suitable utilization of fish resource.
5. Much of the lack in fish production as well as the problems there for should be offset and settled by expanding fish farms (marine fisheries).

5.6 **Limitations of the study:**

1. Because fishery is a renewable resource, it needs longer time of series data, which was not available.
2. Getting some information, that might help to improve the quality of the analysis such as stock assessment, Shanon index to measure the change in species, seem impossible.
3. A reliable data about fish production was not available. For that reason the study was restricted only to the available five years data.
4. Fishermen some times misunderstand the survey purpose and deal with the interviewer as if she is a tax collector. Hence they were reluctant to release information and sometimes intentionally give misleading information.

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