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Chapter 14

The Nile Fishes and Fisheries

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1. Introduction

The Nile basin extends from 4° S to 31° N and includes ten African countries: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda and Democratic Republic of Congo (Fig. 1). The source of the Nile water is one of the upper branches of the Kagera River in Rwanda. The Kagera follows the boundary of Rwanda northward, and continues along the border of Tanzania before draining into Lake Kyoga between Lake Victoria and Lake Albert, the Nile rushes along its course for 483 km within rocky valleys and over rapids and cataracts. The section between the two lakes is called Lake Kyoga and is part of the Victorian Nile, which name is used for the river section till its confluence with the Blue Nile in Sudan. The Nile discharges from the northern end of Lake Albert and flows through northern Uganda to the Sudan border where it becomes the Bahr El-Jebel. At its conjunction with Bahr Al-Ghazal, the river becomes the White Nile. At Khartoum, the White Nile is joined by the Blue Nile.

The 1529 km long Blue Nile has its source in Lake Tana in the Ethiopian Highlands. From Khartoum the Nile flows 322 km north to its junction with the Atbara River. Downstream from its confluence with the Atbara River, the Nile traverses the Nubian Desert, and is marked by two profound bends in its course, the first north of Khartoum and the second near Aswan in the Egyptian territory. The Nile flows towards the Mediterranean Sea through the Nile delta that splits into the two main Nile delta branches, the Rosetta and Damietta branches. The Nile River flows generally north to the Mediterranean Sea for a distance of 5,584 km. From its remotest head-stream, the Ruvyronza River in Burundi, the river is 6,671 km long, and it has a drainage area of more than 2,590,000 km^2 [1].

With a length of 6,695 km from source to Mediterranean outfall, the Nile River is the longest river in the world. The uniqueness of the Nile is not only related to morphometric features of its basin, but to other many facts. No other river traverses such a variety of landscapes, and such a spectrum of cultures and peoples as the Nile. No other river has historically had such

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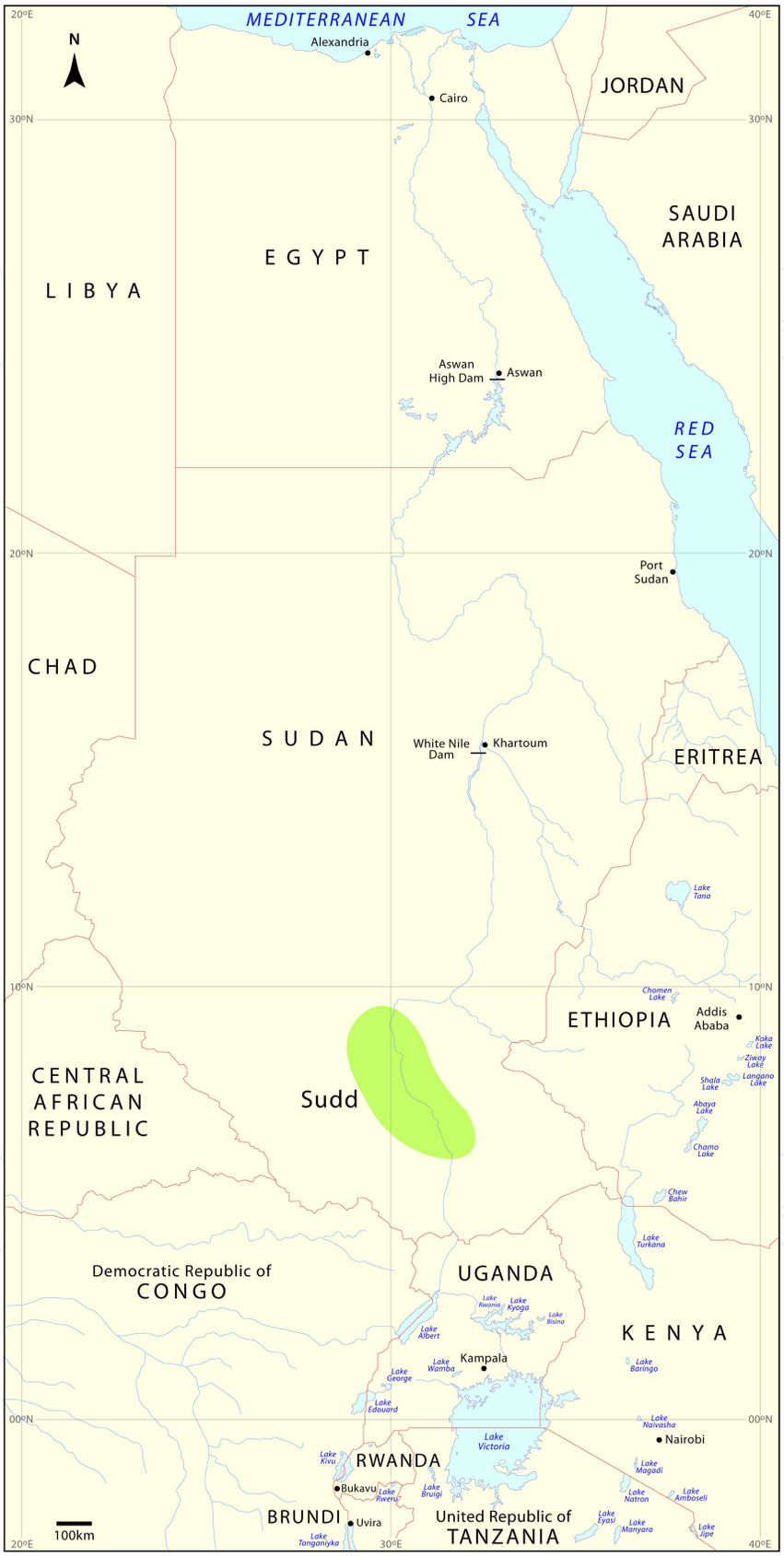


Figure 1. The Nile River trajectory from source to outfall

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a profound material effect upon those who dwell along its banks, representing the difference between plenty and famine, between life and death, for multitudes since the earliest stages of human history [2]. The course of the Nile flows from highland regions with abundant moisture to lowland plains with semi-arid to arid conditions [1].

For Nile basin countries with no access to the coast for economic activities, the Nile River is their artery of life and economic sustenance. Its fertile sediments supply agriculture soil with necessary elements for plant growth, and the fish stock in its large natural and manmade lakes are crucial to the food and freshwater security of the Nile basin countries. Fish industry and fishing activities on the major water bodies of the Nile basin are not only a source of affordable animal protein, especially in poor countries, but also provide employment, income and export earnings to the riparian communities.

The principal objective of the present review is to highlight the main freshwater fishes and the major fisheries of the Nile River basin. The ecological status of the Nile fisheries and their economic importance to populations living in the countries of the Nile basin are also reviewed. The main lakes and river systems of the Nile basin will be compared on the basis of their fish species, fisheries potentiality and economic importance to the countries that host them.

2. Major lakes of the Nile basin

The lengthy course of the Nile River is interrupted by several important lakes. Some of them are natural, while others were engineered by dam constructions and artificial reservoirs projects. Within the Nile basin, there are five major natural lakes with a surface area totaling more than 100,000 km^2 (Victoria, Edward, Albert, Kyoga and Tana). These are vast areas of permanent wetlands and seasonal flooding (the Sudd, Bahr Al-Ghazal, and Machar marshes). There are also five major reservoir dams (Aswan High Dam, Roseires, Khasham El-Girba, Sennar and Jebel Aulia) in the basin. Before discharging its water into the Mediterranean Sea, the Nile fills four coastal lakes within its Delta (Lake Mariut, Lake Edku, Lake Burullus and Lake Manzala) with a total area of 1100 km^2 [2].

The share of the Nile basin area for each of the ten countries hosting the river may represent a major or minor fraction of the total area of the country (Table 1). However, the economic significance of the basin may be quite disproportionate to its area, such as it is for Kenya and Tanzania [3].

Nile waters are the mainstay for freshwater supply for agriculture irrigation, navigation, water for human use ("drinking, industrial, domestic uses"), hydroelectric power generation, and of course for exploitation of natural fish stocks and aquaculture fish farming projects.

3. Fish and fisheries of tropical lakes (L. Victoria and L. Tana)

Fishes and fisheries of Lake Victoria and Lake Tana will be reported here, as natural examples of tropical large water bodies of the Nile basin. The combined surface area of these lakes is

Country	Area in basin (km³)	Percentage of total country area in Nile Basin
Burundi	13 000	46%
D R Congo	22 300	1%
Eritrea	25 700	21%
Ethiopia	366 000	32%
Egypt	307 900	33%
Kenya	52 100	9%
Rwanda	20 400	83%
Sudan	1943 100	78%
Tanzania	118 400	13%
Uganda	238 700	98%

Table 1. National areas within the Nile Basin "Source [14]"

75% of the total of the five tropical lakes of the Nile basin. They are also important because they lie at the source of both the White Nile and the Blue Nile, respectively. Their main fishes are representative of the fish species living in the other lakes (Edward, Albert and Kyoga). Details on the other tropical lakes (Edward, Albert, Kyoga, and George) fish fauna and its fisheries are found elsewhere [4], [5].

3.1. Lake Victoria (Kenya, Tanzania and Uganda)

Lake Victoria is the largest natural lake in Africa (Fig. 1) and the second largest lake in the world after Lake Superior (USA-Canada). It has a surface area of 68,800 km^2 and a very large catchment area of 193,000 km^2. The shoreline measures 3450 km in length and the lake has a mean depth of 40 m and a maximum depth of 80 m. The lake is shared by Kenya (6%), Uganda (43%), and Tanzania (51%). The lake basin is estimated to have a population of 30 million individuals which is growing at a rate of >3% per annum. Three major cities (Kampala, Kisumu and Mwanza) with a combined population of about six million inhabitants depend on the lake for domestic and municipal water supply and waste disposal. Recent data has shown it is becoming eutrophic [6].

Two introduced species, Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromus niloticus*), and one native cyprinid (*Rastrineobola argentea*) dominate the lake's fisheries. The introduction of the Nile perch (*L. niloticus*), in the early 1960's had major ecological consequences. It is believed that some 200 endemic halochromine species (previously comprising 90% of the lake fish biomass) have become extinct in the lake due to predation by the Nile perch [7]. Most of these species had no commercial value, but are now considered relevant to the sustainability of the Lake Victoria ecosystem [8]. Lake Victoria fisheries production has increased markedly since the introduction of the Nile perch. Despite the general unreliability of published data, there is agreement that between the late 1980's and early 1990's there was an increase in the

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quantity of fish landed in Lake Victoria fisheries reaching a total of 500,000 tons per year. This figure was in decline by the late 1990's and early 2000's when it reached a total of 340,000 ton per year (Fig. 2). This reduction was mainly due to the overexploitation of the fisheries resources, and to the increase in the number of motorized boats, and to the Nile perch processing industries. Reportedly the number of fishing boats in the lake increased from 12,000 boats during 1982 to 22,700 boats during 1990 and more than 52,000 boats in 2002 [6]. In recent years, as fishing pressure on the Nile perch has intensified, there are signs of recovery in at least some of the former haplochromine species that were thought to be extinct from the lake environment [9], [10], [5].

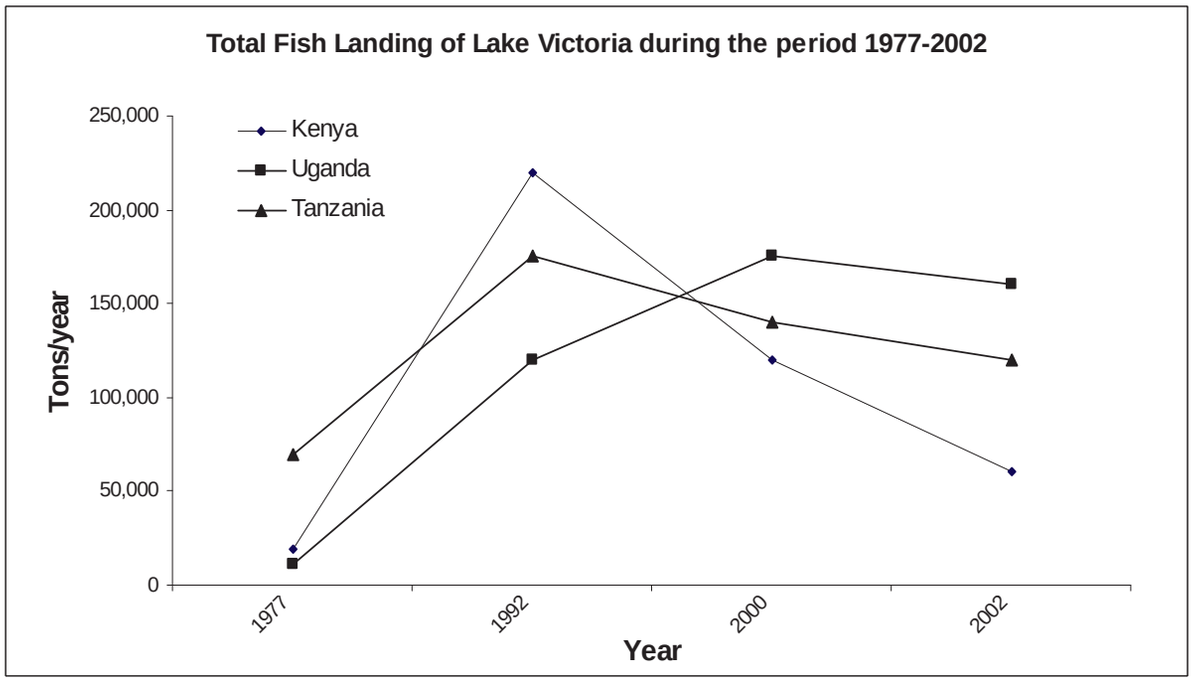


Figure 2. Variation of the total fish landing of Lake Victoria during the period 1977-2002 [8]

Extracted data from the results obtained by [6], from the ECOPATH prediction model have revealed that the stock biomass (tons km^{-2}) of the fishes (Nile perch, tilapia and sardine) are different in the waters of Lake Victoria shared by different countries. The same is also true for the ratios of production per biomass except for the sardine species (Fig. 3). The data also shows that the Ugandan lake areas have lowest stock of Nile perch biomass, while the highest stocks are found in the Kenyan lake areas. Interestingly, the Ugandan stock biomass of tilapia is the highest while the Tanzanian stocks are the lowest. The sardine stock biomass is higher in the Kenyan lake areas followed by the Tanzanian, with the lowest recorded in the Ugandan lake areas (Fig. 3). An overall estimate shows that the average stock biomass for the whole of Lake Victoria is 4.59 tons km^{-2} for the Nile perch, 3.27 tons km^{-2} for the sardine and 2.36 tons km^{-2} for the tilapia. The same trend is observed for the estimate of production/biomass $year^{-1}$, giving the ratios 3.75, 3.0 and 1.75 for the three fishes, respectively.

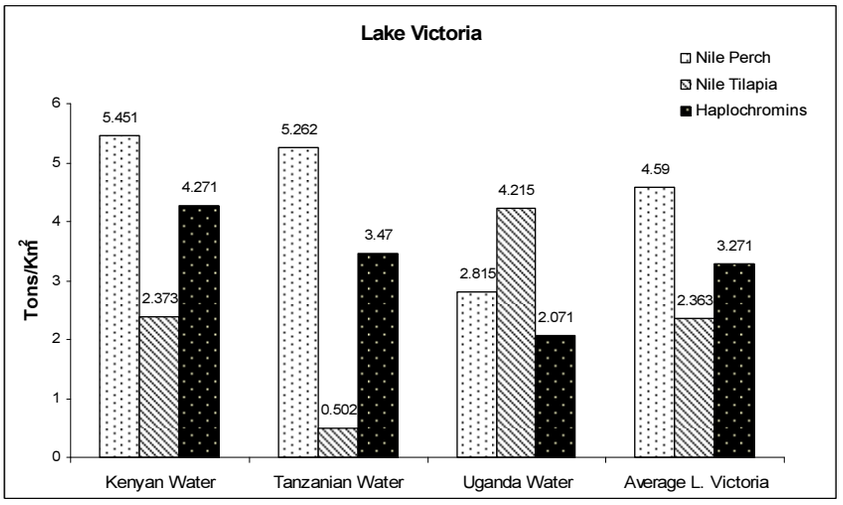


Figure 3. Biomass potentials of different water sectors of Lake Victoria for the main three fish species (tons km^{-2}) [8]

The artisanal fishing gear was in use on traditional fishing boats in Lake Victoria fisheries until the industrial exploitation of the Nile perch for international commercialization. At that time, motorized boats and improved fish gear "even illegal" was used. The most common gear used in Lake Victoria fisheries are gill nets and long-line hooks. During the period of 2000 and 2004, the numbers of gill nets in use increased by 50% reaching 980,000 gill nets, while the numbers of long-line hooks is estimated at 8 million in 2001. This number was adjusted to only 6 million during 2006 [6]. The current haul is estimated at 45 kg boat $^{-1}$ day $^{-1}$ compared with the 80 kg boat $^{-1}$ day $^{-1}$ figure during 1990's. This indicates over-intensive exploitation of the fisheries of Lake Victoria fish resources and argues for sustainable management intervention.

3.2. Lake Tana *(Ethiopia)*

Lake Tana is the largest lake in Ethiopia (surface area 3,050 km^2). It lies at an altitude of approximately 1800 m a.s.l. in the north-western highlands of Ethiopia, 500 km north of the capital Addis Ababa (Fig. 1). The lake is shallow (average depth 8 m, maximum depth 14 m), and its trophic status is described as oligo-mesotrophic [11]. The lake's fishery is 30 km downstream from the Blue Nile outflows, and is isolated from the lower Nile basin by 40m high waterfalls. Physical and hydrological features of the lake water follow a seasonal pattern. Rainfall peaks in July-August are followed by a rise in the lake water level by 1.5 m, reaching highest levels in September-October [12].

In their study, DeGraaf et al. [12] identified the three endemic fish species groups Barbs or yellow fish (*Labeobarbus* spp.), African catfish (*Clarias gariepinus)*, and Nile tilapia *(Oriochromus niloticus)*, as the main representatives of Lake Tana fisheries. They noted that before 1986 Lake Tana was a subsistence fishery exploited predominantly by reed boat fishing vessels. This type of fishery was limited to the shore areas and targeted the native Nile tilapia using locally made fish traps and small gill nets.

In 1992-1993 about 113 reed boats were counted on the lake and about 374 gill nets were in use, with an overall daily haul averaging 12.3 kg (7.8 kg Nile tilapia, 4.3 kg *Labeobarbus* spp. and 0.2 kg African catfish). Here it is important to indicate that *Labeobarbus* spp. in this lake is represented by nearly 15 species. It was also reported at that time that the fishermen in the lake numbered about 400 individuals. This meant that each reed boat had only one fisherman [12]. The introduction of motorboats to Lake Tana fisheries was a consequence of the increasing demand for fish from the capital Addis Ababa. This introduced an additional 130 professional fishermen, which markedly negatively influenced the fish stock in the lake. In fact, the annual total catch fell to 255 metric tons in 2001 from a value of 360 metric tons in 1997. Not only was there a reduction in total catch but also the percentage composition of the individual fish species yield varied between 1993 and 2001, so that the catch of *Labeobarbus* spp. declined by almost third in 2001 compared to 1993. Notably, the catch of Nile tilapia increased 50% in 2001 compared to 1993 (Fig. 4). This may reflect the intensive exploitation of *Labeobarbus* spp. and the superior ability of the Nile tilapia to multiply in the lake.

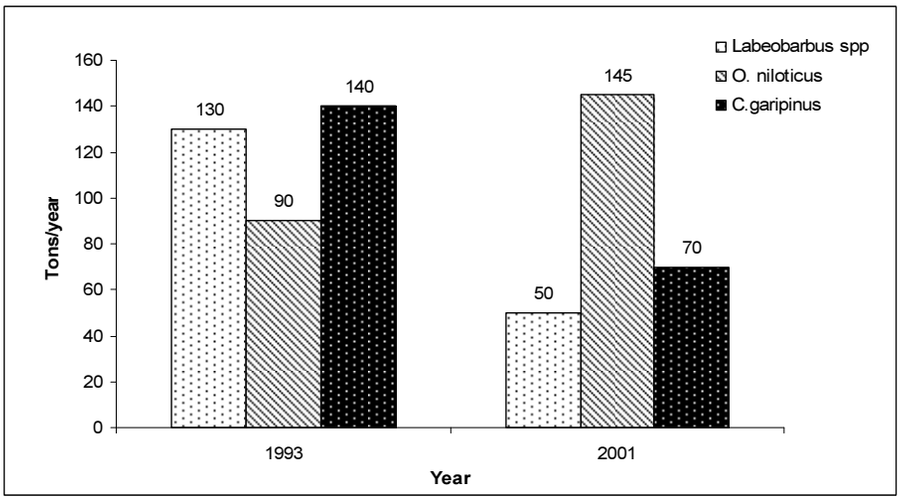


Figure 4. Total catch of the three main species from Lake Tana during the years 1993 and 2001 [13]

4. Fish and fisheries of Mid Nile (Sudan freshwater fish and fisheries)

Although Sudan is a country with a very large surface area (2,505,825 km^2), its inland water bodies occupy only 114,000 km^2 during periods of high water level. The inland fisheries of Sudan are based on the Nile river tributaries, contributing over 90% of the estimated production potential of the country. The Sudd swamps in the south (Fig. 1), and the man-made lakes on the White Nile, the Blue Nile, Atbara river and the main Nile river (Lake Nasser portion in Sudan "Nubia") count as the major fishing localities with respect to fish resource magnitude and exploitation thrust [13]. The total fish production of the various inland water bodies and wetlands are estimated at 50,000 tons year $^{-1}$. This figure is not representative of the full

potential of the various fisheries (Table 2), as in some areas civil war disturbances and dense cover of aquatic macrophytes, and inadequate fishing gear have had a negative effect on local fish production.

Area	Fish Catch Potential Tons year^{-1}	Actual Yields Tons year^{-1}	Percentages of Exploitations
Sudd Region	75,000	30,00	43%
White Nile Reservoir	15,000	13,000	86%
Blue Nile Reservoir	1,700	1,500	88%
Senner Reservoir	1,100	1,100	91%
Lake Nubia Portion	5,100	1,000	19.6%
Others	4,000	4,000	100%
Total	101,900	50,500	≈ 50%

Table 2. Calculated Potential and Effective Fish Catch from Different Inland Water Bodies of Sudan

The predominant fishing gear includes active and passive gill nets, seine nets, trammel nets, long line hooks, cast nets and baskets. The commercially important fish are Nile perch (*Lates niloticus),* Bagrid catfish *(Bagrus bayad),* Silver catfish *(Bagruc docmac),* Nile tilapia *(Oreochromus niloticus),* Carp fish *(Labeo* spp.*),* Barbs fish *(Barbus binny),* Mormyrus fish *(Mormyrus* spp.*),* Nile Distichodus *(Distichodus* spp.*),* Tiger fish *(Hydrocyon* spp.*)* and Nile robber *(Alestes* spp.*).* There are many other species, though they have no commercial value [13].

It is important to state that, apart from the FAO reports, there is almost no scientific literature available on the ecological features and dynamics of fish populations in the inland waters of Sudan. This underlines the importance of organizing a research program on inland fisheries in this area in order to fill the gap of knowledge about the fisheries status in this important part of the Nile basin. This is especially important for the wet lands which are not limited to Sudan but also exist in the ten countries of the Nile basin, and account for an area of almost 200,000 km^2. A characteristic of wetlands fisheries is the variety of traps that are used to catch fish in dominantly submerged or emergent vegetation habitats. Many of these traps have traditional designs adapted to local conditions and most are made from local plant materials - often from wetlands themselves. One type of fish requiring a special fishing technique is the African lungfish (*Protopterus aethiopicus*), which is native to Ethiopian wetlands and inhabits the seasonal wetlands where it aestivates in the dried soil and is "hunted" during the dry season.

5. Downstream fishes and fisheries (Egyptian freshwater fisheries)

Egypt is the downstream country hosting the last 1530 km of the Nile river channel. The Nile enters Egypt through the Nubian Lake which continues as Lake Nasser behind the Aswan High Dam (AHD). The water allowed to pass through the AHD is the Egyptian quota of Nile

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water (55.5 Km^3 $year^{-1}$) as outlined in an agreement with Sudan in 1959. This quantity satisfies the freshwater demands of the Egyptian population for use in agricultural irrigation, industry, domestic and navigation purposes. On the way to its Mediterranean destination, the Nile water fills many canals within the irrigation network in the western desert and the Nile delta. It also contributes to the water budget of the Northern Delta lakes [2]. Thus the freshwater inland water fisheries in Egypt include Lake Nasser (the second largest man made reservoir in Africa, after Lake Volta-Ghana), the Nile main river channel, irrigation channels, some water bodies in the Western Desert, the Nile branches (Rosetta and Damietta), and the Northern Delta Lakes (Manzala, Burullus, Idko and Mariut). The excess water is then discharged into the Mediterranean Sea through the lake connections with the sea via direct and indirect inlet openings [2]

The annual fish yield from freshwater fisheries of the Egyptian Nile basin has increased annually from 157,888 metric tons in 1990 to 224,940 metric tons in 2000 [14]. The catch increased for a number of reasons, such as the nutritive effect of sewage and fertilizer discharge in drainage channels and lakes, the intensified fishing activities and adjustment of incensement statistical techniques. Apart from the intensive aquaculture that has developed during the last twenty years in Egypt, the major contributors to the freshwater fish catch could be listed as Lake Nasser, Nile branches and irrigation channels as well as the northern Delta lakes. Their contribution may be summarized as follows:

5.1. Lake Nasser fishes and Fisheries

Lake Nasser lies behind the AHD and its extension in the northern Sudan is referred to as the Nubia reservoir. This lake has a depth reaching 180m and covers an area of 6216 km^2, 5248 km^2 of which are in Egypt and the rest in Sudan (Fig. 1). The total fish catch from Lake Nasser has been estimated as 28,153 tons $year^{-1}$ [15]. Tilapia species, mainly the Nile tilapia represent 90% of the total fish catch, while Nile perch and *Barbus* spp. cover the remaining 10%. Despite the large area of the lake, it contributes only about 10% of the total freshwater fish landing in the Egyptian Nile basin. This is probably due to its deep waters and the low number of motorboats with suitable fishing gear adapted to its bathymetry.

5.2. Nile branches and irrigation channels fishes and fisheries

There are more than 100 sites recorded along the Nile branches and major irrigation channels at which freshwater fishes are collected for marketing. Most fishermen in these areas are not registered. The fishing fleets at these sites comprise hundreds of small wooden boats (4-6 m in length). The fishing gear used is mostly primitive, though trammel nets are in use in some areas. The common fish species caught from these channels are tilapia species (*O. niloticus, O. aureus, Sarotherodon galilaeus* and *Tilapia zilli*) as well as *Clarias* spp.

Although these fishing sites are sparsely distributed and reliable statistics are in short supply, it has been estimated that 34% of the total Egyptian freshwater fish catch is slated to the two main Nile branches (Rosetta and Damietta) and the major irrigation channels [16].

5.3. Northern Delta lakes (NDL)

As the final reservoirs of Nile river water before it flows into the Mediterranean, the four lakes (Mariut, Edku, Burullus and Manzalah) are the last opportunity for Egyptians to use the Nile water within the Delta area (Fig. 5). The four lakes occupy an area of about 1100 km². They are commonly shallow (average depth 1.10m), and their water salinity is known to change from fresh to brackish in the seaward direction. They are connected to the Mediterranean Sea either directly or indirectly.



Figure 5. The Northern Nile Delta lakes

During the last 50 years, the surface area of the four lakes has been reduced to as little as 50% of the area they covered during the 1950's (Table 3). The lake areas lost have been used for highway construction, reclamation of new lands for agriculture, and in some cases, for residential constructions. Such unnatural use of the lake basins has certainly modified their ecosystems as a whole, beginning with hydrological changes and resulting in the reduction of their economic and natural value. Due to their location along the coastal area of the Egyptian Mediterranean, the lakes are surrounded by or included within the highly populated coastal cities of the country. This has become more pronounced, particularly during the last 20 years, in the various forms of human impact on these water bodies, such as industrialization and the construction of new infrastructures in response to population density increases. These impacts are manifested in the deterioration of the water quality and reduction in lake surface area [17]. The consequent negative effect of human impact on the NDL ecosystems became evident in the decline in fish production. Up to 1985 the annual fish production of these lakes accounted for >50% of the total annual yield for the country.

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Year's	L. Mariut	Edku L.	L. Burullus	L. Mazalah
1950's	136.9	150.1	571.8	1274.2
1970's	68.4	129.2	534.4	997.3
1980's	66.1	115.3	481.6	904.1
1990's	62.3	109.7	350.8	650.3

Table 3. Gradual changes in the surface areas (Km^2), of the Northern Delta Lakes during the last 50 years "After, [17]"

According to the year 2001 records, the lakes fisheries had a total fish production of about 140,000 tons year $^{-1}$, which represented about 60% of the freshwater fish catch and about 30% of the total annual yield of Egypt [16]. The main freshwater fish species living in the NDL are Nile tilapia (*Oreochromis niloticus),* Blue tilapia *(O. aureus), Mango tilapia (Sartherodon galilaeus)* and *Tilapia zilli* also known as *Tilapia melanopleura,* Nile perch *(Lates niloticus),* Bagrid catfish *(Bagrus bayad),* Nile carp *(Labeo niloticus),* Yellow fish *(Barbus prince),* Barbus fish *(B. bynni bynni), and* African catfish *(Calrias gariepinus).* Other species, such as Grey mullet *(Mugil cephalus),*Thinlip grey mullet *(Liza ramada),* Saline mullet *(Liza salinus) and Eel fish Anguilla anguilla,* belonging to the brackish-marine sectors of the lakes, represent a minor part of the total catch of these lakes. The fishing fleets and gear used in the lakes are generally primitive and they are adapted to the shallow water depth and the presence of abundant emergent and submerged macrophytes. Thus wooden boats varying in size from 4 to >20 m in length and a number of net types and sizes are used.

6. Water quality in Major Nile basin fisheries and its impact on fish production

6.1. Water quality in the upstream basins

Studies of water quality of the Nile basin and its channels and lakes have demonstrated a trend of lower water quality in the downstream basins compared with those located upstream. This is mainly due to the following:

The all-year round continuous flow of the river from south to north which dilutes existing pollutants and contaminants and carries them downstream.

Less industrialization of upstream countries compared to the downstream ones.

Neither water multi-use nor recycling processes are common practice in upstream countries compared with the downstream ones.

Low population densities and less modernized sewage systems at upstream countries compared with the downstream ones.

In addition to the above, the main impact of human activities in the areas surrounding the upstream Nile river water bodies may result from the uncontrolled drainage and discharge of

agriculture fertilizers, insecticides, herbicides and untreated sewage into the Nile basin. This is probably true for Lake Victoria and Lake Tana, since industrial pollution and discharge of inorganic pollutants are more limited. However, in these upper parts of the Nile basin, the existing civil wars and the absence of hygiene have resulted in periodic devastating epidemics such as cholera and other infectious diseases that may also negatively influence fisheries production either directly or indirectly.

Studies of Lake Victoria water quality have indicated that notable changes in physical, chemical and biological features of the lake ecosystem have occurred during the last three decades. These changes have resulted in increasing eutrophication and decreasing water transparency and decreasing dissolved oxygen concentrations at the hypolimnion layer during periods of stratification [18], [19]. These studies indicated also that water eutrophication in Lake Victoria is a direct result of nutrient enrichment from human activities in the catchments area as well as industrial and domestic sewage discharge from combustion processes. That is in addition to soil erosion and fertilizers' washout through drainage since the introduction of tea, cotton and maize farming.

Recent studies of pesticide residues in Nile tilapia and Nile perch from southern Lake Victoria has implications of recent exposure of these two species to DDT and endosulfan isomers. The study concluded that most of the analyzed samples contained residue levels higher than the method detection limits, though below or within the Accepted Daily Intake (ADI) limits [20]. Other studies have indicated that spraying of endosulfan in cotton fields near Tana River (Kenya) result in levels of fish contamination [21], [22].

The most surprising finding of these studies is the detection of these compounds in fish but not in local sediments and water. It has been found that the high demand for fish has pushed some Lake Victoria fishermen to use DDT as a mean to catch fish in certain areas of Lake Victoria. The reason of the absence or the inability to detect such compounds in the lake sediments could be due to dilution effect of the running water in these basins which made their residuals below the detection limits.

6.2. Water quality in the Mid-River basins

In Sudan the water quality of the southern wetlands (Sudd area) depends on how much water is supplied annually to its basins. The continuous alteration of wetlands by human activities and their utilization for other purposes have negatively influenced both the quality and the quantity of water reaching this area. The redirection of water away from the Sudd for human activities has resulted in the formation of isolated ponds, promoting water stagnation and growth of macrophytes, and weeds. These practices have negatively influenced the capacity of fisheries in this part of the Nile basin.

At Lake Nasser, where both the White Nile and the Blue Nile water mix in different portions, the residues of Nile water contaminants from the upstream countries via Sudan reach this huge man-made reservoir shared by Sudan and Egypt. Lake Nasser water quality is affected also by the continuous fluctuation of its water level. In this regard, most of the studies focused on detecting contaminant levels in the lake water and its effect through bioassay experiments of

living biota. Unfortunately, these types of studies did not show the full effect of these pollutants on fish and the degree of pollution of the lake water. Recently, a monitoring study of a range of heavy metals (Co, Cr, Cu, Fe, Mn, Ni, Sr, and Zn) in Nile tilapia fish of different ages (1, 1.5, 2, 2.5 and 3 years) from Lake Nasser was undertaken by [23]. This study examined the trace element concentrations in water, sediments, and aquatic plants, as well as different edible and non-edible fish organs at different ages. The study showed that both water samples and aquatic plants have higher levels of Fe compared with concentrations detected in fish edible parts (muscles). On the other hand, the concentrations of the various metals in sediments were higher than their concentration in fish muscles. The author concluded that the concentrations of Co, Cr, Cu, Fe, Mn, Ni, Sr, and Zn in the edible parts of the examined Tilapia fish were within the recommended permissible levels for human consumption (Table 4).

Elements	Zn	Sr	Ni	Mn	Fe	Cu	Cr	Co
Aquatic plantMean (µg/g DW)	175 (±6)	240 (±9)	19(±1.2)	740 (±8)	1720 (±14)	68 (±6)	29 (±1.1)	35(±1.6)
SedimentMean (µg/g DW)	143 (±2.9)	455 (±12)	122(±3.2)	1000 (±19)	51500 (±24)	109 (±2.6)	79 (±2.0)	89.5 (±2.6)
WaterMean (µg/g DW)	230 (±0.84)	1852 (±18)	145 (±1.02)	186 (±0.9)	1420 (±8)	220 (±1.1)	240 (±0.58)	185 (±0.8)
FishMean (µg/g DW)	1.55 (±0.08	1.92 (±0.99)	0.19 (±0.25)	0.5 (±0.066)	6.45 (±1.1)	0.27 (±0.08)	0.29(±0.22)	0.25 (±0.05)

Table 4. Heavy metal concentrations in fish (*T. nilotica*), aquatic plant (*N. armeta*), sediment and water samples from Lake Nasser. "Modified from, [23]". DW, dry weight; (±), Standard deviation

6.3. Water quality in the downstream basins

In their location farthest downstream in Nile basin, the Nile Delta branches (Damietta and Rosetta) and the Northern Delta Lakes (NDL) are, not surprisingly, the most polluted and have the lowest water quality. The trophic status in these water bodies has been described in the scientific literature as varying between eutrophic and hypertrophic conditions [17], [2]. The continuous aggressive human impacts on the water bodies of the NDL since the 1950's until now have resulted in various negative consequences, beginning with the reduction of their surface area (Table, 3), and increase of nutrients discharge through agricultural, industrial drainages and domestic sewage; and leading to the dramatic decline of their fisheries [24]. Both domestic and industrial sewage represent a major source of nutrient enrichment of water bodies of the Nile delta. These contribute significantly to the development of the eutrophication phenomenon and the consequent degradation of water quality. In a number of cases, municipal and rural domestic wastewater is discharged directly into waterways. The constituents of domestic and industrial input to water

resources are pathogens, nutrients, trace metals, suspended solids, salts and oxygen demanding materials [25]. Siegel [26] reported that the nutrient base for aquaculture in Lake Manzalah is sewage carried by drains from as far away as Cairo, 140 km to the south. He added that untreated or poorly treated industrial wastes, heavy metals and other pollutants have been released into the Nile Delta drainage network and have been discharged, along with sewage and agriculture wastes, into the northern delta lakes and their associated wetlands. Studies of sedimentary deposits in the southeastern sector of Lake Manzalah have detected different trace metal concentration. They have detected Hg (up to 822 ppb), Pb (up to 110 ppm), Zn (up to 635 ppm), Cu (up to 275 ppm), Cr (up to 215 ppm), Sn (up to 14 ppm) and Ag (up to 4.7 ppm). The results suggest that high concentrations of heavy metals in lake sediments may cause contamination in fish, especially bottom feeders in such environments [26]. This may be the case in the northern lakes, since all of them receive the sewage discharges of major cities.

Location	Sampling	HCB	DDTs	PCBs	Γ-HCBs
River Nile					
Cairo	1993	<0.001	0.08-0.12	3-640	0.05-0.07
Rosetta Branch	1998	1-77	0.2-99	5-161	
Damietta Branch	1988	<DL-93	90-102	25-53 7-21	<DL-126
Nile Estuaries					
Rosetta	95-97	197-217	83-97	166-181 390-430	286-310
Damietta	95-97	195-240	109-128	270-330 581-700	312-352
Coastal Lakes					
Lake Manzala	1993	0.03-0.18	0.10-0.56	18-48	0.37-1.57
	92-93	0.84-2.28	26-55 3-26	<DL-20	8.6-12.1 1-11

Table 5. Concentrations (ng/l) of HCB, DDT's, PCB's and lindane in freshwaters from different locations of the Nile Delta- Egypt "Modified from [27]" <DL: below detection limit

Although both agricultural drainages and sewage discharges into the lake environments may be considered as sources of nutrient that can compensate the nutrients reduction in the Nile water after the construction of Aswan High Dam (AHD), these discharges have different pollutants, such as organochlorine compounds, which are not only harmful to the fisheries but also to the consumers of fish. In his study, [27] noted that the use of organochlorine insecticides in Egypt began in the 1950's and was extensively used until 1981 to protect crops from insects, disease fungi and weeds, to remove undesired vegetation and for domestic household use in

the control of insects. The reported active ingredients of major organochlorine pesticides during a 30-year period include: toxaphene 45,000 Mt (1955-1961), endrin 10,500 Mt (1961-1981), DDT 13,500 Mt (1952-1971) and lindane 21,000 Mt (1952-1978) [28]. DDT is still in limited use in the country as a rodenticide and termiticide. These pollutants are released into drainage canals and reach the delta branches and NDL. According to the data provided by the Ministry of Agriculture, the application of pesticides decreased in the country, from 20,500 tons in 1980 to 16,435 tons in 1995. Since chlorinated pesticides have been banned, the majority of the pesticides currently in use are organophosphorus compounds [27]. Table 5 shows concentrations of PCB's, DDT's, HCB and Lindane present in the water bodies located in the Delta region.

7. Freshwater aquaculture in the Nile basin

Freshwater aquaculture activities in the Nile basin countries depend on the following main factors:

1. The status of fish as a main food source according to the customs of the local populations

The existence of a market demand for specific fish living in the local river and lake waters

The economic value of these activities for the private sector compared with other projects

This is clearly demonstrated by the estimation of aquaculture production within the Nile basin countries (Table 6). Although Lake Victoria produces almost 25% of the freshwater fish catch in Africa, the aquaculture productivity of countries sharing the basin of Lake Victoria is very limited. This could be due to the lack of interest of the private sector in developing aquaculture activities, since the Lake production easily satisfies local and international market demand. In Uganda the number of ponds totals 6200, covering a total area of 124.6 ha. In some of these ponds yields of about 10,000 kg ha^{-1} y^{-1} were recorded. The most widely distributed species are mirror carp and various tilapia species. However, since the Nile perch is the most popular fish for export, there is little interest in developing aquaculture. It is expected that future expansion in freshwater farming in this part of the Nile basin is promising, especially when the fish stock at Lake Victoria become overexploited.

Although freshwater aquaculture was not commercially practiced in Sudan until 1990, the population density increase and local market demands have encouraged large scale aquaculture of freshwater fish, especially Tilapia species. The main demand comes from the capital Khartoum, where population density is rising, with growing interest in tilapia fish as an alternative source of animal protein [3].

In Egypt, where water conservation is becoming the highest priority, the reutilization of drainage water from other activities has assisted private sector investment at aquaculture activities in general and freshwater fish farms in particular. This has been spurred by the Egyptian tradition of consuming fish as an essential food item. The local market demand for fish has increased tremendously during the last three decades due to population growth.

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996 -	2007
Burundi	25	24	25	30	50	50	55	55	50	10	200
DR Congo	723	759	760	700	700	730	700	750	750	750	2970
Eritrea	-	-	-	-	-	-	-	-	-	-	-
Ethiopia	-	1	33	36	36	22	28	33	55	85	-
Egypt	45000	50000	55000	55916	877	54195	45380	46887	45473	53302	635516
Kenya	126	251	603	698	722	749	763	813	893	500	4240
Rwanda	64	38	44	164	58	53	53	50	49	50	4038
Sudan	43	45	100	234	203	200	200	200	1000	1000	1950
Tanzania	35	37	375	375	400	350	200	150	200	200	10
Uganda	38	34	42	52	63	77	87	179	194	210	51110

Table 6. National aquaculture production in the countries of the Nile Basin [29], [30]

Consequently, the price of captured fish has risen, assisted further by the degradation of the natural fisheries. The result was that fish moved out of the affordable range for poor people. The high price of fish was remedied by freshwater aquaculture, which is a very well-known practice in Egypt since 1930. Although records were not available at that time on the size of production, the FAO statistical services sector was able to establish records of the Egyptian fisheries and aquaculture beginning in 1950. These records indicate that the total fish catch from aquaculture has linearly increased up to 539,748 tons year $^{-1}$ in 2005 (Figure 6). This quantity represents not only aquaculture freshwater fish but also brackish and marine cultured ones. Data suggests that >60% of this quantity consists of freshwater fishes, mainly Tilapia species.

During the last two decades, and due to the reutilization of drainage water, the salinity in these water bodies has increased, leaving them brackish. These changes in water salinity are paralleled by changes in the cultured fish species. In fact, most of the fish farms responded to changes in water salinity by turning from Tilapia to carp fish farms and then to grey mullet. The total income of produced fish from aquaculture in Egypt is estimated at 971,846 * 10^3 US $ per year (Figure 6), according to the available estimate of 2005 [14]. Based on these figures it is estimated that the supply of fish per capita has increased from 7 kg year $^{-1}$ in 1990 to 15 kg year $^{-1}$ in 2003. In fact, Egypt is not only the leading country in the Nile River basin in freshwater aquaculture (Table 6), but also the first amongst the Mediterranean countries and the Arab world [31], [29], [3], [13], [14].

8. Economic value of freshwater fisheries of the Nile basin

There is no doubt that freshwater fisheries provide an essential supply of animal protein to large parts of the developing world. At national, community and family levels these systems

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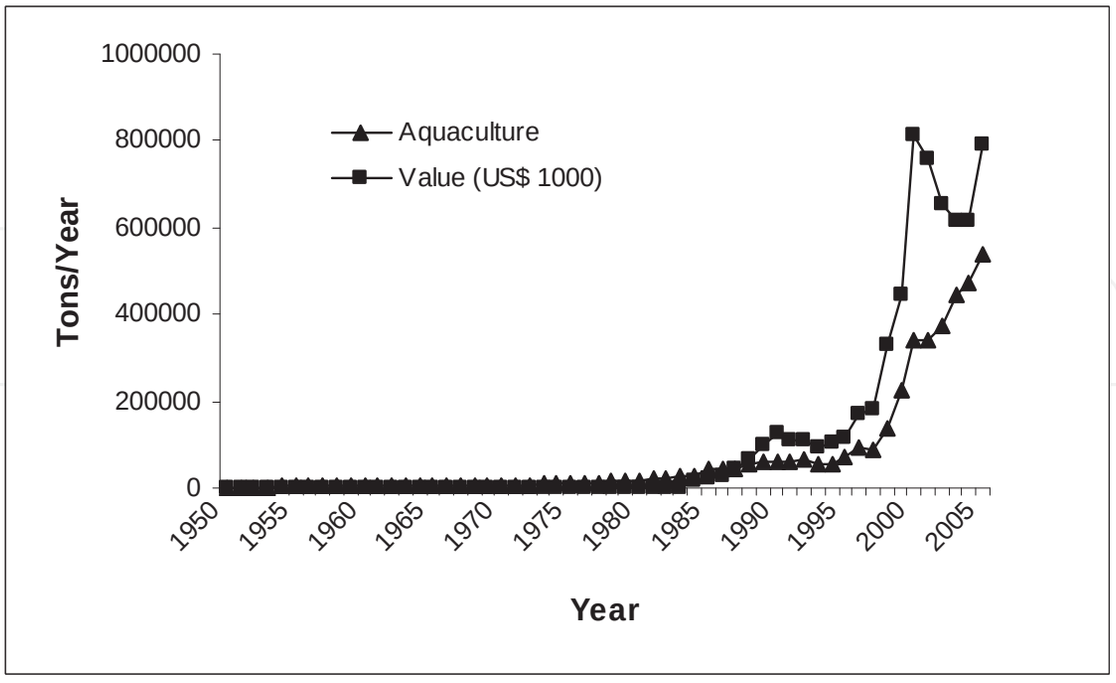


Figure 6. Aquaculture fish production in Egypt and its Economic value during the period 1950-2005 [14]

are critically important in sustaining food security. However, this is not the case for the upstream countries of the Nile River basin, where, although the great lakes have abundant fish production, there is a lot of concern about malnutrition of the populations surrounding the basin. An example is provided by Lake Victoria which supports Africa's largest fishery. Its most valuable product is the Nile perch, much of which is exported. This has given rise to arguments claiming a direct linear relationship between perch exports and disturbingly high rate of malnutrition along the lake's shore [32]. This state of affairs is mainly due to the foreign fish processing companies that control the fish exports, and the high demand on the Nile perch especially in the EU countries. With such high demands for Nile perch, the value of the fisheries has risen considerably. In 1983, there were 12,041 boats operating on the lake. By 2004, there were 51,712 boats and 153,066 fishermen. Of the 1433 landing sites identified in 2004 along the lake shores, just 20% of the population had communal lavatory facilities, 4% were served by electricity and 6% were served by potable water supply [32]. The authors have concluded that, Policy options can include targeting health care specifically at the lake's communities. They also added that local organizations such as LVFO (Lake Victoria Fishery Organization), should translate the largest inland fishery benefit into discernible positive impact on the ground. That means positive economic return has to be reflected on fishermen families.

The Ugandan portion of Lake Victoria fish is among the highest revenue foreign exchange earner for non-traditional exports. In fact, the fish exports registered unprecedented growth in earnings, coming second after coffee exports in 2001. Its proportional contribution to export earnings rose from 5% in 1994 to 17% in 2001. It is estimated that fish exports in 2001 were in the order of 28,000 metric tons, with a value of approximately US$ 78 million. That estimate is

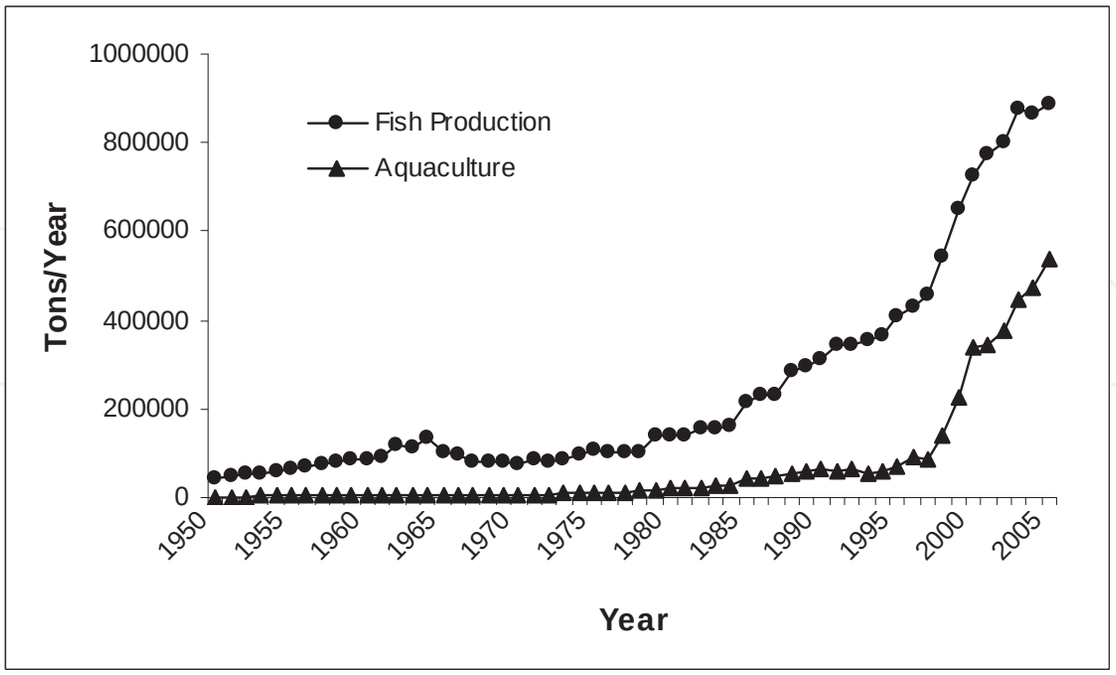


Figure 7. Growth trends in total fish production in Egypt (marine and freshwater catch) compared with aquaculture during the period 1950-2005 [14].

only for the Nile perch. Other estimates included Nile tilapia from other countries bordering the lake (Kenya and Tanzania). These account for a total catch of 110 metric tons. However, the difference in value is marked, since the Nile perch is exported to EU countries, while the other species and small size Nile perch are locally consumed or regionally exported at lower prices. Recent statistics on the annual total fish production of the three countries (Kenya, Tanzania and Uganda) from Lake Victoria is amounted to 960, 500 tones [30]

In Sudan freshwater fisheries contribute very little to the national economy, especially as the estimated fish consumption per capita is only 1.7 kg year $^{-1}$. In general, the fishing industry in 2003 is estimated to have exported 1,629 tons of fish with a value of US$ 533,000, while a quantity of 157 tons was imported for local consumption at a cost of US$ 324,000. This means that the total earnings from fish production did not exceed US$ 200,000 representing only 0.4% of the national GDP [13].

As previously highlighted, Egyptian fisheries, including both natural fisheries and aquaculture represent the largest producers of freshwater fishes within the Nile basin countries. This is mainly due to the rapid growth in freshwater aquaculture production, amounting to about 60% of the national total fish catch (Figure 7). Despite high fish production, the fishing industry plays a relatively minor direct role in the economy of Egypt. Nevertheless, domestic fish production makes a valuable contribution to the national food supply and to the traditional way of life, for which fish eating remains an important part. In addition, it is a significant source of food for the tourist industry.

Fishing industry is also important for the livelihoods of over 65,000 fishermen and other people employed full-time in related activities (estimated at some 300,000 men). The fish industry in Egypt also produces fish powder (from non-edible fish) of about 543 tons to be used as nutritive food additives in poultry farms [13].

9. Future of freshwater fish production of the Nile basin

Without exception, the freshwater fisheries in the Nile basin countries are under severe and constantly stressful conditions. The Nile fisheries have continued to deteriorate despite its impressive freshwater resources and the many efforts by national and regional institutions with national and international support. This decline is mainly due to the rapid increase in population densities surrounding the water bodies of the Nile basin, which has negatively influenced the water quality of these basins and their fisheries. In addition, overexploitation of the fish resources has advantaged non-commercial and invasive species in their competition with native and economically valuable ones. The lack of regulatory fishing plans and management policy in most of the Nile basin fisheries has also added complexity to any future strategic plans to safeguard such valuable resources. In order to manage this important sector along the Nile basin there is a need to:

- Make appropriate information data available to guide decision makers
- Enforce laws and sustainable management of fisheries resources and the fish habitat.
- Control the use and dumping of Pesticides residuals in the Nile basin
- Promote sustainable practices with the help of scientific knowledge.
- Provide adequate financial resources and human capacity to implement fisheries program.
- Investigate and improve the socio-economic status of fishermen.
- Regulate fishing gear and practices that may otherwise damage fish stocks and habitat.

The poverty of many of the diverse populations living along the Nile basin remains a barrier to the implementation of concepts of natural resources conservation, despite the many efforts of governments and NGO's to disseminate this information.

Faced with a continuing large gap between global supply and demand for fish protein, with critical shortage in some regions, aquaculture is widely regarded as having a crucial role to play in meeting global and regional food requirements over the next 20 years. Aquaculture can be a water efficient means of food production, and also brings wider resources management benefits. To this end, it is advisable that the Nile basin countries take advantage of the existing water resources and encourage the private sector in implementing aquaculture activities as an actual and future alternative of animal protein and as a substitute for the degraded natural fisheries of the Nile basin.

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References

[1] Roskar, J., 2000. Assessing the water resources potential of the Nile river based on data, available at the Nile forcasting center in Cairo. Geografski zbornik. 53:32-65.

[2] Hamza, W., 2006. Estuary of the Nile. In: Wangersky P. (Ed.), *Estuaries;* Hdb. Env. Chem. *Springer Verlag Publisher*, Vol. 5 H: 149-173 pp.

[3] FAO, 2000. Nile basin initiative report to ICCON "Water and Agriculture in the Nile Basin", Land and water development division AGL/MISC/29/2000 Rome 1-68pp.

[4] Witte, F., van Oijen and N. Sibbing, 2009a. Fish fauna of the Nile. In: Dumont H.J. (ed.), The Nile. Monographiae Biologicae, Vol. 89:647-675. Springer, Dordrecht.

[5] Witte, F., M. deGraaf, O.Mkumbo, A.I. El-Moghraby and F. Sibbing, 2009b. Fish fauna of the Nile. In: Dumont H.J. (ed.), The Nile. Monographiae Biologicae, Vol. 89:647-675. Springer, Dordrecht.

[6] Matsuishi, T., L. Muhoozi, O. Mkumbo, Y. Budeba, M. Najiru, A. Asila, A. Othina and I. G. Cowx, 2006. Are the exploitation pressure on the Nile Perch fisheries resources of Lake Victoria a cause of concern?. Fisheries Management and Ecology 13 (1) 53-71.

[7] Witte, F., T. Goldscmidt, P. Goudswaard, W. Ligtvoet, M. van Oijen and J.H. Wanink, 1992. Species extinction and concomitant changes in Lake Victoria. Netherlands Journal of Zoology 42: 214- 232.

[8] Balirwa, J.S., C.A Chapman, L.J. Chapman, I.G. Cowx, K. Geheb, L. Kaufman, R.H. Lowe-McConnell, O. Seehausen, J.H. Wanink, R.L. Welcomme and F. Witte, 2003. Biodiversity and fisheries sustainability in the Lake Victoria basin: an unexpected marriage? Bioscience 53: 703-716.

[9] Cowx, I.G., M. van der Knaap, L. I. Muhoozi and A. Othina, 2003. Improving fishery catch statistics for Lake Victoria. Aquatic Ecosystem Health & Management, 6(3): 299-310.

[10] Njiru, M., J. Ojuok, A. Getabu, T. Jembe, M. Owili and C. Ngugi, 2008. Increasing dominance of Nile tilapia, *Oreochromis niloticus* (L) in Lake Victoria, Kenya: Conse-

quences for the Nile perch *Lates niloticus* (L) fishery. Aquatic Ecosystem Health & Management, 11(1): 42-49.

[11] Dejen, E., J. Vijverberg, and F.A. Sibbing, 2004. Temporal and special distribution of microcrustacean zooplankton in relation to turbidity and other environmental factors in a large tropical lake (L. Tana, Ethiopia), Hydrobiologia 513: 39-49.

[12] DeGraaf, M, P.A.M. van-Zweiten, M.A.M. Machiels, E. Lemma, E. Dejen, and F.A. Sibbing, 2006. Vulnerability to a small scale commercial fishery of Lake Tana's (Ethiopia) endemic Labeobarbus compared with African catfish and Nile tilapia: an example of recruitment-overfishing? Fisheries Research 82: 304-318.

[13] FAO, 2002. Fishery country profile, FID/CP/SUD. February, 2002.

[14] FAO, 2008. FAO Fisheries and Aquaculture Information and Statistics Service (Egypt). http://www.fao.org/fishery/countrysector/FI-CP_EG/1

[15] Earth Trend, 2003. Water resources and freshwater ecosystems-Egypt. Available online (www.earthtrends.wri.org).

[16] GAFRD. 1995-2002. Annual fishery statistics reports (General Authority for Fish Resources Development), Cairo-Egypt.

[17] Hamza, W., 1999. Differentiation of phytoplankton communities of Lake Mariut: A consequence of human impact. Bull. Fac. Sci. Alex. Uni. 39 (1-2): 159-168.

[18] Mugidde, R., 1993. The increase in phytoplankton production and biomass in Lake Victoria (Uganda). Ver. Internat. Verein. Limnol. 25: 846-849.

[19] Bootsma, H., & R.E. Hecky, 1993. Conservation of the African Great lakes: a limnological perspective. Conservation Biology 7: 644-656.

[20] Henry, L., M.A. Kishimba, 2006. Pesticide residue in Nile tilapia (Oreochromis niloticus) and Nile Perch (Lates niloticus) from Southern Lake Victoria, Tanzania. Environmental Pollution 140: 348-354.

[21] Munga, D., 1995. DDT and endosulfan in the fish from Holla irrigation scheme. M.Sc. Thesis. University of Nairobi, Tana River, Kenya.

[22] Wadinga, S.o., 2001. Use and distribution of organochlorine pesticides; The future in Africa. Pure and Applied Chemistry 73:1147-1155.

[23] Rashed, M.N., 2001. Monitoring of environmental heavy metals in fish from Nasser Lake. Environment International 27: 27-33.

[24] Oczkowwski, A and S. Nixon, 2008. Increasing nutrient concentrations and the rise and fall of a coastal fishery; A review of data from the Nile Delta-Egypt. Estuarine, Coastal and Shelf Science. 23: 189-219.

[25] Hamza, W. & Mason, S., 2004. Water availability and food security challenges in Egypt. Proceedings International forum on Food security under water scarcity in the Middle East: Problems and Solutions. Como- Italy 24-27 Nov., 2004.

[26] Siegel, F., 1995. Environmental geochemistry in development planning: an example from the Nile delta, Egypt. Journal of Geochemical Exploration. 55: 265-273.

[27] Barakat, A., 2004. Assessment of persistent toxic substances in the environment of Egypt. Environment International. 30: 309-322.

[28] El-Sebae, A.H, Abou Zeid, M., & Saleh, M.A., 1993. Status and environmental impact of Toxaphine in the third world- a case study of African agriculture. Chemoshere. 27:2063-2072.

[29] FAO, 1998. Aquaculture production statistics-1987-1996. FAO Fisheries Circular, No. 815, Revision 10 [FIDI/C815] Rome.

[30] FAO, 2009. Fisheries and Aquaculture statistics. http://www.fao.org/statistics

[31] FAO, 1994. Seminar on freshwater culture, Damascus, May 2-4, 1994; Edited by MEDRAP II Regional Center Tunis-Tunisia.

[32] Geheb, K., S. Kalloch, M. Medard, A. Nyapendi, C. Lwenya and M. Kyangwa, 2007. Nile perch and the hungry of Lake Victorai: Gender, status and food in an East African fishery. Food Policy- Elsiver (in press).

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