Review Article

INTENSIFICATION OF FISH PRODUCTION IN EGYPT

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Contents

INTRODUCTION

In Egypt the potentialities of fish culture industry are great. This is due to the presence of the following natural resources: a) the long seashores bordering the north and east coasts of the country, b) the long river Nile crossing the country from the high dam at south to the Mediterranean sea at the north, c) the numerous small branches making a large net of water stream either supplying the lands by irrigated or draining water, and d) some big lakes with brackish water scattered all over the country (Morsy, 1994).

The need for rapid development and proper management of the fishery is becoming a necessity in view of the high demand for fish as a relatively cheap source of animal protein. Fish may compensate the present deficiency of other expensive sources. Aquaculture is the science and technology of producing aquatic plants and animals (Lawson, 1995). While aquaculture has been practiced in Egypt for thousands of years, systematic aquacultural research to increase fish pond yields in Egypt is relatively new (Green, 1995). By "aquacultural systems" we mean the commercial production systems of aquatic animals either in controlled or uncontrolled environment (Bala and Satter, 1989). Aquaculture plays an increasing important role in the world fishery production. It has been the world's fastest growing food production system for the past decade. The world fish production of aquaculture increased about more than three times through the period from 1988, about 7.5 million tons to 22.0 million tons in 2000. This increase is a result of intensification of production from the existing fish farms and the expansion of areas under cultivation (El-Ebiary 2002). Fish culture systems are increasingly intensive, largely due to the shortage of water and land and labor resources. There is also a need in Egypt for quick production of market-size fish to meet the demand of an increasing population (Sadek et al., 1992).

Intensification in aquaculture is defined as management in which more fish are produced per area unit, by complementing of substituting the natural food web in culture environments with external inputs such as feeds and fertilizers and by supporting cultured populations with oxygen and biofiltration whenever necessary (Mires, 1995).

Intensification is an option which has to be evaluated economically and practically. The degree of intensification is characterized mainly by the density of stocking. The choice of the rate of production depends on the existing business environment, i.e market infrastructure, competitors, and potential prices, as well as the availability of various essential inputs, such as (a) fry and fingerlings, (b)basic farm infrastructure, such as sufficient water supply and roads, (c) specific feed ingredients, (d) energy, usually electricity, (e) professional know-how, and (f) equipments i.e. aerators, transportation facilities, and seine nets.

1. The state and development of aquaculture:

Rainfall in Egypt is very light with a mean annual average of about 50 mm in the delta region. Rainfall decreases both eastwards and southwards reaching maximum of 180 mm recorded for Alexandria. Evaporation rate in open waters is about 1500 mm/year in the delta region increasing along the north-south axis reaching up to 4000 mm/year in the desert region. Water temperature in the north during winter tend to drop below levels considered safe for some warm water fish species (El-Gamal, 1997).

However, winters in Egypt are mild with an average temperatures in January of about 10°C while the average summer temperature vary between 26°C on the coast and about 30°C in Cairo area. The fish farming zonation suggests that only the south eastern corner of Egypt is suited to all round intensive production of temperate fish species. In general, the warm weather that Egypt enjoys provides advantages in having extended growing season as well as having early spawning for some fish species shared with countries in the Mediterranean region such as seabass and seabream. The temperature system also points out the importance of overwintering of fish species that are not tolerant to cold such as tilapia.

There have been a number of reviews of aquaculture in Egypt (Sadek, 1984; Balarin,1986; Barrania and Sadek, 1994; FAO, 1994; Shehadeh and Feidi, 1996; El-Gamal, 1997 and 2001). This article reviews and updates selected aspects of aquaculture with emphasis on resource limitations.

1.1. Water and land availability

Water resources are by far the most limiting factor to be considered in aquaculture development. The expected increase in water consumption as well as the present threat of draught have made water conservation a priority. The Ministry of Public Work and Water Resources began in 1977 implementing water reuse program. Drainage water could be regulated in the future as farmers are starting to re-use this water for crops as well. Moreover, a new water policy has been set targeting more control on water use in crop production which in turn will lead to reduce the quantity of drainage water available for aquaculture especially the use of water for crop production has priority over aquaculture (El-Gamal, 1997).

The use of water directly from the supply canals is allowed only for governmental hatcheries and not for fish farms which are currently using water from the drainage canals. However, the integrated system of rice-fish culture is an example for multiple use of first use water for rice/fish production. New sources of water needed to be surveyed for aquaculture development. Marine waters are the immediate promising sources of water needed for development. However, some conflicts with other activities (tourism and urban development) do exist in regard to the potential use of marine sites. Ground water has potential in the development; it has been adequately exploited yet.

Fish farms are limited to areas classified as waste lands not suitable for agriculture mainly because of their high salt and alkali content and poor drainage. Within 1-2 years of water flooding, soil salts are leached, thereby improving the quality of the soil and become in direct competition with agriculture. This may explain the decline in the area of land under pond culture to about 11,500 ha at 1993 after its utmost peak in 1987 at 45,500 ha as a result of rapid increase in the reclaimed lands in the early eighties and the utilization of aquaculture as a productive and temporary means of desalinating new lands. In general, the priority allocation of land is given to agriculture. Unlicensed fish farms are some how disturbing the official statistics (FAO, 1994).

1.2. **Production**:

Egypt has the earliest recorded history of fish-farming in Africa, superseding even carp culture in the Far East (Shehadeh and Feidi, 1996). In 1994, it accounted for about 48% (by quantity) of total aquaculture production from Africa (FAO, 1996). Fish culture in ponds accounted for 87.72 % of total aquaculture production in 2001 (342,864 tons), fish culture in rice fields 6.92% (23,716 tons), and cages 5.36% (18,371 tones). The total area under pond culture in 2000 was about 160,066 feddans. Private farms accounted for 143,214 feddans (89%) and government farms 16,852 feddan, or 11%. About 110,308 (69% of total pond area) consisted of unlicensed farms; i.e. farms using arable land. Rice-fish culture is practiced in 233,600 feddans in 1998, while cage culture in the Nile provided a modest production volume of about 285,490 cubic meters in 2000 which produced 28,553 tons with an average of 10 kg/m^3 (Megapesca, 2001).

Aquaculture and fisheries in Egypt is an important component of the agricultural sector and a significant source of animal protein. It accounts for 3.9% of agricultural production and 14.1% of total livestock and poultry production by value (FAO, 1994). The sector directly employs about 164,000 people, representing 3.07% of employment in agriculture. It also provides additional employment for 20,000 people in supporting services and industries (Shehadeh and Feidi, 1996). Estimated total fish production in 2001 was 771,515 tons, of which aquaculture accounted for 44.44% (including carp production in rice fields); marine fisheries 17.26%; lake fisheries 24.30% and River Nile 14% of total production. Production by source during the period 1992 to 2001 is shown in Table (1). One of the major features of the pattern of production is the rapid increase in contribution of aquaculture, with 570% an increase in nine years since 1992 (Fig 1). Output doubled between 1998 and 1999 to 226,277 tons, and in 2001 production increased by a further 50% to 342,864 tons (GAFRD, 2001). The most species of fish production in Egypt are tilapia (40% of production from all sources) and grey mullet (about 14%). These two groups account for more than half of all fish produced (Fig 2).

Table (1): Fish production (tons) in Egypt during the period of 1992-2001

Source/ Year	1992	2001	1992-2001
Sea fisheries			
Mediterranean	43,385	59,624	+37.43%
Red Sea	43,349	73,549	+69.67%
Lakes			
Manzala	58,519	78,400	+34.00%
Burullus	52,251	59,200	+13.30%
Bardawil	1,838	3,146	+71.16%
Idku	8,300	10,910	+31.45%
Maryut	3,143	6,200	+97.26%
Qarun	1,435	1,396	- 2.72%
Nasser	33,000	28,153	-14.69%
Fouad	200	162	-19.00%
Elrian	546	861	+57.69%
Morra and Timsah	700	5,444	+677.7%
Rivers and canals			
Nile and canals	39,623	109,887	+177.3%
Fish farming			
Ponds	34,755	300,777	+765.4%
Rice fields	25,000	23,716	-5.14%
Cages	245	18,371	+7398%
Total fish farming	60,000	342,864	+570.4%
Total production	346,289	771,515	+122.8%
of which fish farming)	17.33%	44.44%	

GAFRD (2001)

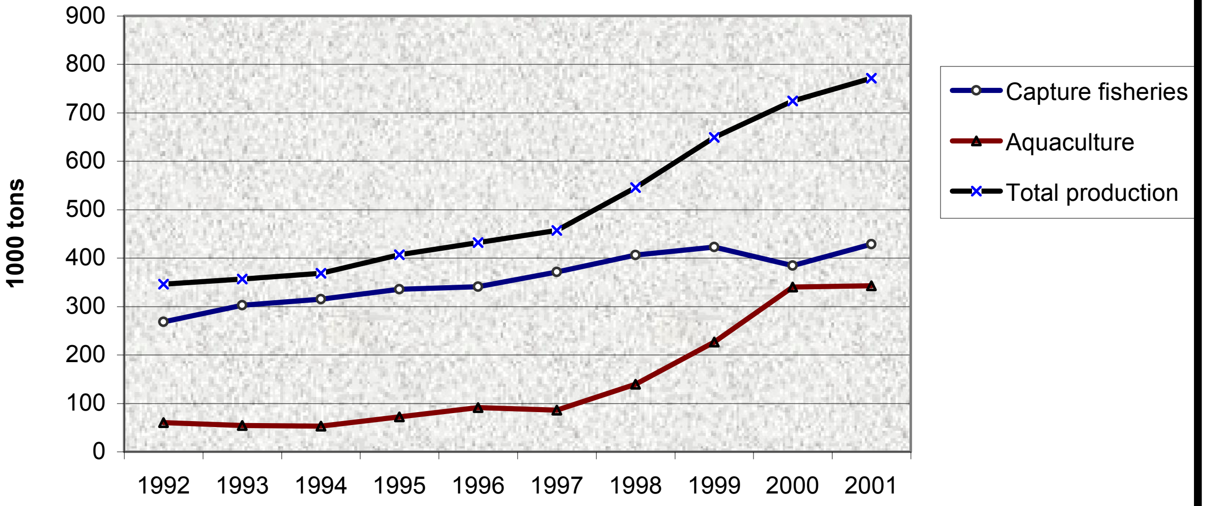

Fig (1): Contribution of aquaculture of total fish production in Egypt

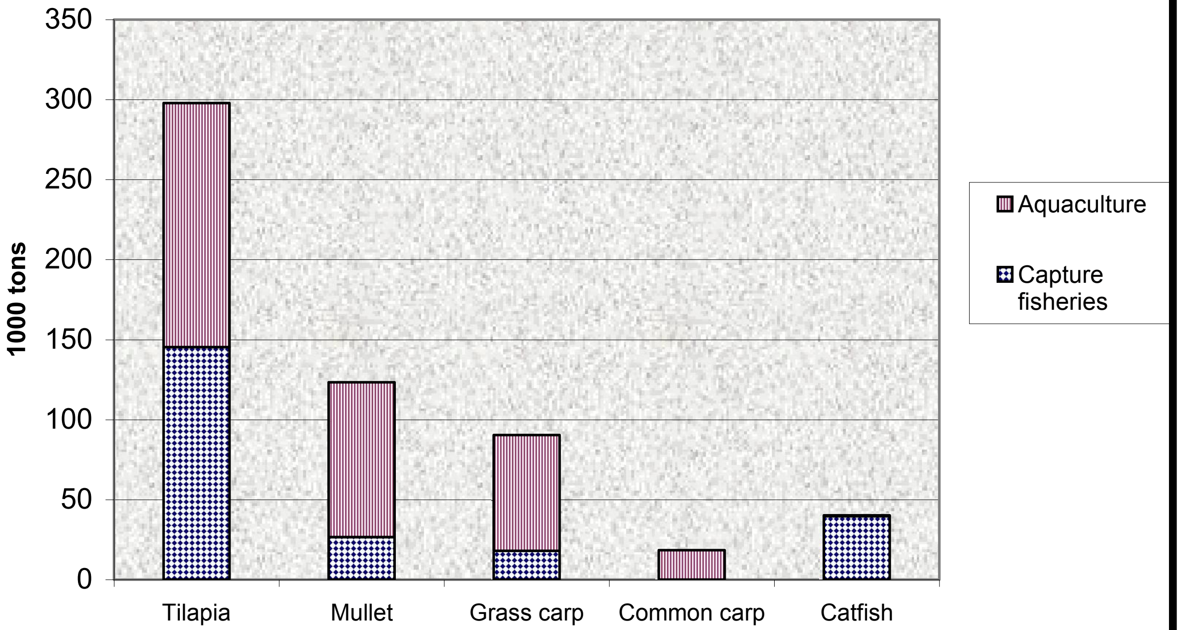

Fig (2): Sources of cultured fish species in Egypt in 2001

Fish production by governorates:

According to GAFRD (2001) it is noticed that, fish production in Egypt is not regularly distributed on the Egyptian governorates (Table 2). Whereas, Kafr El-Sheikh produced 29.01%, Matrouh produced only 0.05% of the total fish production in Egypt and this may be due to the availability of production inputs such as land, water, fry and also the presence of natural fisheries in Kafr El-Sheikh.

Table (2): Fish production (tons) by governorates in the year 2001

Governorates	Fisheries		Fish culture		Total production	%
	Production	%	Production	%		
Kafr El-Sheikh	67,017	15.63	156,832	45.74	223,849	29.01
Dameitta	24,950	5.82	55,551	16.20	80,501	10.43
Dakhlia	67,086	15.65	5,460	1.59	72,546	9.40
Sharkia	5,959	1.39	47,309	13.80	53,268	6.90
Gharbia	8,591	2.00	0	0	8,591	1.11
Menofia	19,439	4.53	0	0	19,439	2.52
Kalubia	9,253	2.16	0	0	9,253	1.20
Suez	34,826	8.12	750	0.22	33,576	4.61
Red sea	33,390	7.79	0	0	33,390	4.33
South Sinai	5,333	1.24	30	0.01	5,363	0.70
Alexandria	11,432	2.67	1,521	0.44	12,953	1.68
Beheira	30,352	7.08	20,376	5.94	50,728	6.58
Matrouh	379	0.88	5	0.0001	384	0.05
Sohag	5,266	1.23	429	0.13	5,695	0.74
Quna	6,461	1.51	0	0	6,461	0.84
Aswan	34,538	8.05	0	0	34,538	4.48
Port Said	15,707	3.66	16,233	4.73	31,940	4.14
North Sinai	7,586	1.77	26,603	7.76	34,189	4.43
Ismailia	7,997	1.87	2,985	0.87	10,982	1.42
Cairo	3,888	0.91	0	0	3,888	0.50
Giza	6,247	1.46	5	0.0001	6,252	0.81
Fayoum	2,704	0.63	5,705	1.66	8,409	1.09
Beni Sweef	5,140	1.20	882	0.26	6,022	0.78
Menia	8,366	1.95	2,130	0.62	10,496	1.36
Asyout	6,544	1.53	18	0.0005	6,562	0.85
El-Wadi El-Gadeed	200	0.05	40	0.01	240	0.03

Source: GAFRD (2001)

Kafr El-Sheikh Governorate considered a good example for development of fish intensification in Egypt. Based on GAFRD (2001) Kafr El-Sheikh Governorate produced 29% of the total fish production in Egypt (fisheries and fish culture) in the year 2001 (15.63% of fisheries and 45.75% of fish culture). Fish culture in Kafr El-Sheikh started in 1975 with “Howash” system where any production inputs (fry or feed) were not used and production systems well gradually developed and the semi-intensive system was established in the last years. According to El-Dawansy (2002) development of fish farming in Kafr El-Sheikh Governorate could be classified into the following successive stages:

1. First stage (1976-1986): In this stage "Howash" system was used for trapping fish, no fry or feeds and fertilizers were used in the production process and the natural food considered the only source for fish feeding, therefore, a low fish production was gained 75-100 kg/feddan at the best cases of *M. capita* and mullet, *M. cephalus*. The total area for each pond ranged between 20-30 feddans.
2. Second stage (1987-1989): as a result of enhancing of the pond productivity by organic fertilization (poultry manure), fish production in this stage increased to 175-200 kg/feddan of *M. capita* and tilapia.
3. Third stage (1990-1993): in this stage a relatively small ponds were constructed (10-15 feddan for each pond) and water depth increased to 50 cm, also organic fertilization rate was increased beside supplemental feeds (yellow corn and macaroni wastes) were used. Fish fry stocked at a rate of 1200-1700 tilapia + 1500 *M. capita* + 300 mullet, *M. cephalus* /feddan, therefore fish production increased to 650-750 kg/feddan.
4. Fourth stage (1994-1996): management of ponds were developed in this stage whereas a relatively small ponds were constructed (5-10 feddan for each pond) and water depth increased to 1 meter. Ponds fertilized by each of organic and inorganic fertilizers beside supplemental feeds and the net yield reached to 1200-1500 kg/feddan.
5. Fifth stage (1997-2000): this stage characterized by:
   1- The size of each pond was limited to not more than 2.5-3.0 feddans with 1.25-1.50 meter in depth.
   2. Stocking of monosex tilapia fry as a main fish specie at a rate of 12,000-17,000 fry/feddan.
   3. Pond fertilization with organic and inorganic fertilizers.
   4. Using a balanced diets (17-25% protein).
   5. As a result of using these production inputs, fish production increased to about 3 tons/feddan

6- Semi-intensive stage (2001-2002):

The semi-intensive system was established in small earthen ponds (1 feddan/ponds and 1.25-1.50 m in depth). Fish stocking rate increased to 20,000 tilapia (monosex)+1500 *M. capita* fingerlings. Construction of smaller ponds is certainly more expensive, but allows more efficient intensification, mechanization, easier manipulation if feeding, fertilizing, harvesting and disease control. Complete diets (35% CP) were used during the first month of growing season at a rate of 7% of the total biomass while, 30% complete diets were used during the second month at a rate of 5%. After the second month, the 25% complete diets were used at a rate of 3% until harvesting.

Under these conditions, fish production increased to 7 tons/feddan. Also, there are many attempts to applying the intensive fish farming system in earthen and concrete ponds.

Today, there are a total area of 60,000 feddan used as fish farms in Kafr El-Sheikh Governorate. These farms supplied with agricultural drainage water and produce 150,000 tons/year with an average of 3.5 tons/feddan and the net returns of 8,000-10,000 LE/feddan was recorded[(1)]. Cage culture also was established in 1500 cages in Kafr El-Sheikh Governorate in 2002[(1)]. Productivity of these cages was still lower than that presented in Dameitta Governorate because of the poor management of cages. Fish feeding of the caged fish depending on poultry manure (as feed) beside the supplemental feeds. The proper feeding for these cages will be improve productivity of these cages.

Availability of monosex tilapia hatcheries is one reason for the fast development of fish farming in Kafr El-Sheikh Governorate. Today there are about 235 tilapia hatcheries that produce more than 600 million fry units[(1)] (monosex). Also, there were attempts to produce tilapia fry at earlier February by supplying fish hatcheries with water boilers and greenhouse for fry rearing. By this method, fingerlings will be available earlier than the normal spawning season and this helps the farmers to obtain two crops (two production cycles)/year and doubled the fish yield for the same production area.

1.3. <u>Fish supplies to market and consumption:</u>

Fish consumption per capita are shown in Table (3). Annual increase in population is assumed to be in the region of 2%, whilst supplies of fish for human consumption have increased at an average of 13% during the 9 years period from 1992-2001. Annual consumption of fish per capita has increased from 8.42 kg/annum in 1992 to an estimated 15.79 kg in 2001 (GAFRD, 2001). Fish consumption during the decade has grown significantly, an average rate in the region of 9-10% per year.

Imports have continued to play an important role in fish supplies to the Egyptian market, accounting for a relatively constant 23% of domestic consumption. Net imports have risen from about 133,260 tons in 1992 to about 261,430 tons in 2001 (Fig 3), although there were some strong fluctuations during the decade. Most of imports were small pelagic fish such as mackerel and herring. The main sources were UK, Norway and Holland. Imports enter processing (smoked herring and salmon) or are sold directly to consumers.

In comparison, exports of fish are negligible. After mid-1998 exports were reduced even further by loss of access to the EU market due to lack of sanitary controls in compliance with EU Directives. The main exports were fresh fish, frozen cephalopods, and fresh and frozen bivalve molluscs (clams).

According to statistics of GAFRD (2001), aquaculture has made a very significant impact on improving the supplies of fish for human consumption, rising from 60,000 tons in 1992 (12.51% of supplies) to 342,864 tons in 2001 (33.19% of supplies to market). Since 1994 about half of the increase in consumption and in per capita consumption has been provided by aquaculture. Therefore, aquaculture development had a significant impact on the supply pattern of fish to the Egyptian market. Egyptian people presently eat about twice as much fish now than they did 10 years ago (Fig 4), and about half of the increase is due to improved supplied from aquaculture.

Table (3): Fish consumption during 1992-2001

Fish (tons/year)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Production	346,289	356,733	368,184	407,032	431,643	457,036	545,593	648,939	724,407	771,515
Imports	133,260	105,760	165,430	141,740	144,110	207,360	176,300	193,160	213,630	261,430
Consumption	479,549	462,493	533,614	548,772	575,396	664,396	721,893	842,099	938,037	1032,945
Population estimate (Million)	54.082	55.201	56.344	57.510	58.755	60.080	61.341	62.639	63.976	65.336
Consumption/capita (kg)	8.82	8.33	9.44	9.53	9.80	11.02	11.74	13.43	14.64	15.79

Source: GAFRD (2001)

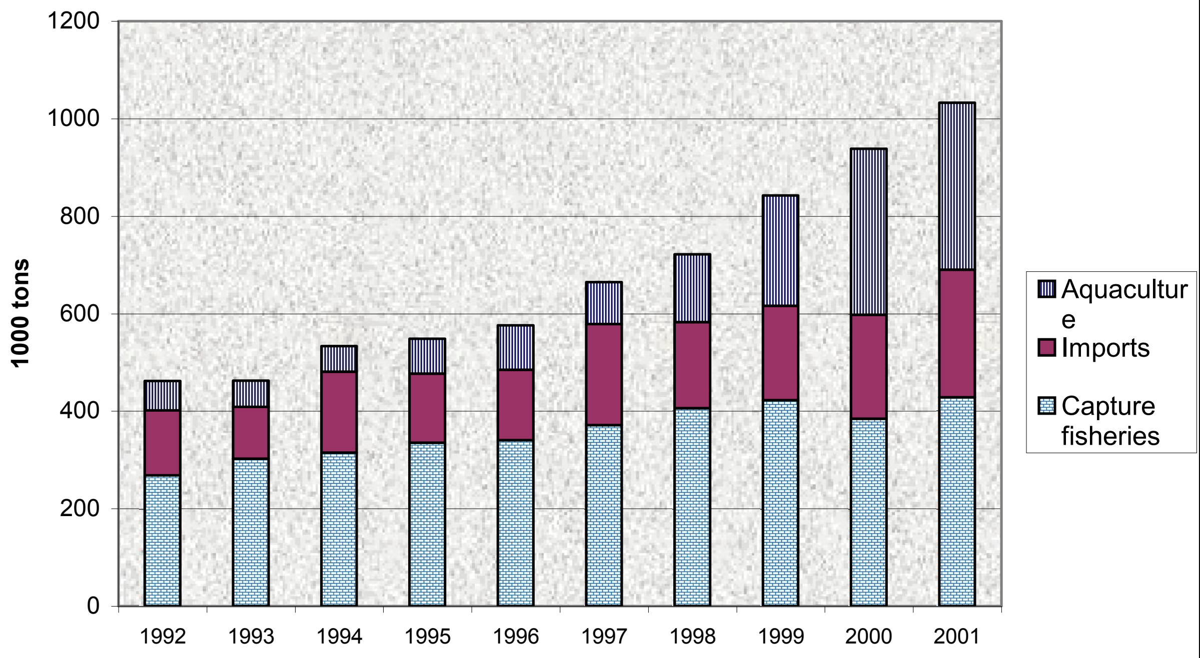

Fig (3): Sources of fish for human consumption in Egypt

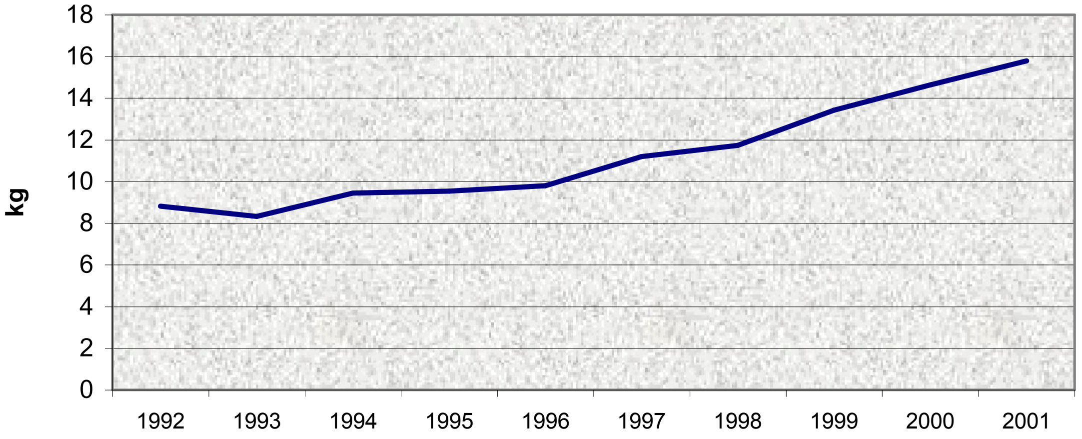

Fig (4): Fish consumption/capita (kg) in Egypt (2001)

1.4. Existing aquaculture practices in Egypt:

Egypt has been the traditional leader in aquaculture production in the middle East region. Egyptian aquaculture started with the use of traditional extensive technique. Rapid development has occurred in recent years, after aquaculture had been identified as the best answer to reduce the increasing gap between supply and demand for fish in Egypt.

Progress was very slow until the last 1970s, then rapid change occurred in all forms of aquaculture activity, including the development of support infrastructure (i.e. hatcheries and feed). This resulted in a noticeable increase in the production of cultured fish (El-Gamal, 2001).

A variety of production systems are in use, ranging from lake stocking to production in enclosures, ponds, cages, tanks, and rice fields. The systems have been described in detail by Balarin (1986) and Sadek (1984). The majority of fish farms in Egypt can be classified as semi-intensive brackish water farms. This type of farms is increasingly vulnerable because of the competition for land and water between this activity and the requirements of land reclamation for agriculture, and the numbers are anticipated to drop significantly.

Intensive culture in earthen ponds and tanks is now developing quickly as a response to the potential drop in number of the extensive farming units. The success of this trend depends largely on the new private-sector groups that have joined the fish-farming activity. These groups have adopted higher levels of production technology and use more responsible approaches to resource use. Private farms now represent 89% of the area occupied by fish farming, and most of these are individual entities, although there are six cooperatives. A national development strategy aims to increase the annual per capita consumption of fish and to ensure the availability of low-priced fish to the consumer, either from national production or from imports.

1.4.1. Extensive aquaculture

The extensive aquaculture is carried out in earthen ponds or in floating cages located in natural water compounds. Extensive culture is defined as "management highly dependant on the natural food web and physical conditions of the natural environment". Thus, in the extensive systems, fish farmers use organic and chemical fertilizers to intensify primary production in ponds and avoid additional inputs of feed and characterized by the low fish production (Mires, 1995). Extensive aquaculture presented in Egypt in different forms:

Re-stocking of lakes with fish fry and fingerlings:

Extensive aquaculture is applied in inland lakes, rivers and irrigation canals in Egypt. Brackishwater lakes (e.g. in the Ryaan Depressions, 16,000 ha, of 4 ppt salinity) are mainly stocked with mullet and carps (silver, bighead and grass carp), in 1980 the first Depression supplied by 2 million carp fry also since 1985 the first and third Depressions annually supplied with 27 million mullet fry. Also, lake Qarun (23,000 ha of 36 ppt salinity) is mainly stocked with mullets (*Mugil cephalus, Liza ramada* and *L. salina*). Stock enhancement programmes were made in lake Qarun with sole (*Solea vulgaris* in the 1960s and European seabass, gilthead seabream and green tiger shrimps in the late 1970s. During the period, 1982-1987 Qarun lake restocked by 365 million mullet family fry. Also, Maryut lake supplied with 20 million mullet fry annually (Mansour, 1994).

These programmes were done to support artisanal fisheries and to reduce the decline in productivity, since most of the freshwater species that used to inhabit lake Qarun had disappeared because of the increase in salinity (El-Gamal, 2001).

Stocking of grass carp in the Nile:

The river Nile and the irrigation network of the Nile valley have been stocked with grass carp for weed control since 1994. Since the black carp is an effective mollusc predator, it can be considered for biocontrol of mollusc, that serve as intermediate host for human parasites (e.g. Schistosoma), or parasites relevant to fish culture, such as the yellow and white grubs in channel catfish and stripe bass farming therefore, black carp has been stocked since 1997. While these activities are done within the national project for biological control, they provide considerable support for fisheries in the Nile valley. Out of a total catch of more than 65,000 tons, about 12,000 tons represent the harvest of stocked grass carp. These projects are managed by the General Authority for Fish Resources Development (GAFRD), development programme and financed by both the Ministry of Irrigation and the Ministry of Public Health.

Canals, ponds and lakes in the different oases in the western desert are stocked with tilapia and common carp to supply the local population with fresh fish. The first harvest were recorded in 1985.

Enclosures:

Fish farming in enclosures is an old practice in Egypt, recently it can be classified as traditional or modern. The traditional is named "Howash" or "Tahweeta". This system is usually followed in the northern delta lakes especially Manzala and Burrolus (Thomas, 1983). The Howash are primitive enclosures built in the low lying grounds from the shore out into the water. The walls are made from reeds packed with mud to form permeable walls. The "Howash" size varies from one to 25 feddans water, water depth ranges from 0.1-1.5 m. In this type the small fish will be trapped and kept to grow till the appropriate size. The disadvantage of such a system is that it is nonselective regarding species and sizes. Rarely, additional feeding is applied in "Howash". Production rates vary from 150-750 kg per feddan, according to management system. Tahweeta is a similar method of trapping fish for some time till the marketable size. The modern enclosures are pen and cage cultures. This system is gaining more publicity among farmers and it is recommended for both fresh and brackish water. It is also suggested to replace "Howash" with pen-fish culture (Hamza, 1989).

Pond culture

The most common practice in fish culture in Egypt for both fresh and brackish water systems is pond culture (Hamza, 1989). The area of fish ponds ranges from one to 30 feddans stocked with 1-3 fish/m^3. The average water depth is 0.5 m within a range of 0.3 to 1.5 m. The water, in most cases, is not flowing. The production rates vary accordingly and range between 200 and 1000 kg/feddan/year. The production rate is rather low in most small scale fish farms due to lack of proper management.

The extensive aquaculture system applied in earthen ponds represents that of the lowest inputs throughout the production cycle and also the minimum control. Sometimes, this system is helpful in utilizing agricultural by-products that cannot be used in higher category systems.

The coastal fish farms (10,948 feddans) in the Dameitta Governorate, which operate within a water salinity range of 20 to 40 ppt, are the main brackishwater-marine farms. They are well designed, with water depth of 1-1.5 m. Water (20 ppt) is drawn from Lake Manzala and drains by gravity into a common area which connects to the Mediterranean. Ponds are stocked predominantly with mullets; seabass and seabream are also stocked when fry are available (Shehadeh and Feidi, 1996).

Production rates in ponds vary with pond depth, use of inputs, water management and salinity. The use of production inputs is extremely variable even with the same production system, due to differences in water depth and salinity, pond productivity and the availability of water and seed. Average production of about 1.6 t/ha/year (maximum of 2.5 tons/ha/year) is reported from some governmental and private farms using polyculture systems, fertilizers and supplementary feeds; about 300-800 kg/ha/year from the majority of the area under culture. Production in the coastal ponds of the Dameitta Governorate varies from 250 to 1,200 kg/ha/year, depending on inputs and water (salinity) management (Shehadeh and Feidi, 1996).

As expected, the risk factors are at their lowest in such systems but, because of the increasing value of natural resources (especially water and land), the low productivity obtained explains the trends of "upgrading" to higher culture categories that allow more efficient use of water, land and labour. Production of one kg of fish needs around 12 m^2 of land and 25 m^3 of water. The most feasible solution to overcome such problems is to develop a semi-intensive fish farming (Ali, 1999).

1.4.2. <u>Semi-intensive aquaculture:</u>

As the term indicates, "semi-intensive' reflects a higher degree of intensification and greater control over the culture habitat. More feeds are used, and of better quality (especially manufactured feeds and more fingerlings are used within a given volume of rearing system). A key result is the improved use of natural resources due to higher productivity levels. Higher investment and skills are needed to establish and operate such a system.

Semi-intensive aquaculture provides about 75 % of Egypt's total aquaculture production (El-Gamal, 2001) and most farms are located in the northern or eastern parts of the Nile Delta. The water supply for these farms comes from agricultural drainage water. There is great variation in the degree of intensity, types of input, level of management and the size and type of infrastructure. This type of farming covers about 187,200 ha, while the average productivity ranges between 0.7 to 4.3 tons/feddan/yr. Tilapia contributes 44% of the annual harvest, followed by mullets (25%). Seabass and seabream contribute 3.5% each within the total.

The semi-intensive culture of tilapias is particularly ideal in developing countries because it provides a wide variety of options in management and capital investments. Management strategies in lower levels of intensification involves the use of fertilizers to encourage natural productivity and to improve the levels of dissolved oxygen. The stocking rate is ranged between 5-10 fish m^3. Fish yields from such techniques have been found to be higher than those from natural unfertilized systems (Green, 1992). Diana et al., (1994) evaluated three feeding regimes for Nile tilapia, feeding regimes studied were feed alone; feed + fertilizer of fertilizer alone, the net yield of tilapia did not significantly different among these regimes. Moreover, increases in fish yields above attained by fertilization only require the use of feed-fertilizer combinations, which result in higher critical standing crop. This increment occurs either by allowing for an increase in fish size or a higher stocking rate. The fertilizer-feed management technique boosts fish yields but also offers the possibility of reducing feed inputs (Teichert-Coddington and Rodeiguez, 1995).

1.4.3. Intensive aquaculture

While not very common in Egypt, about five farms are using super-intensive concrete ponds, tank culture to produce 500 tons of fish per year, mostly tilapia (El-Gamal, 1997).

This culture is practiced in some private and governmental farms. In this system ponds or cages were stocked with different species at high stocking rate which reached to 20 fish/m^3. Stocked fishes are fed on the artificial diets with suitable protein and energy content and fish production ranging between 5-10 tons/feddan/year.

Concrete ponds:

Concrete ponds are being used for rearing different fish species either freshwater or marine fishes, especially to overcome the problem of shortage the suitable lands for aquacultural purposes, or when the intensive fish culture are required. In Egypt, there are a few farms that use these ponds in intensive fish production (Fig 5) and these ponds limited to intensive fish culture and fry rearing in fish hatcheries because the high costs required for ponds construction and the other equipments.

Tank culture

Tank culture (Fig 6) one of the methods that used in fish intensification and fry rearing in fish hatcheries. A high degree of control over the production operation is a must for the intensive system, leaving few options to mother nature. Nutritionally complete feeds are essential for growth, while continuous water exchange and/or supplementary aeration are usually required. Smaller ponds (than in semi-intensive farming) or tanks/raceways are used for better management. Because of the high investment and production costs, farms using 'intensive" technology are developed after careful economic study and are usually applied to the raising of high-value fish, such as seabass or seabream. El-Tal El-Kabeer farm one of the few farms in Egypt that used the high technology for intensification of fish production in Egypt. Also, Fouki farm, (25 km north of Cairo) was outdoor designed to produce 120 tons of tilapia per year in addition to 3 to 5 million hybrid tilapia fry. The fish culture system consists of eight circular galvanized steel tanks (diameter = 12 m; height 1.5 m; volume 150 m^3; concrete foundations) underground water used for supplying the ponds with water (salinity, 2.77 ppt). Sadek et al., (1992) carried out an experiment in this farm to evaluate the production and economical efficiency for fish intensification. They tested three stocking rates of Nile tilapia, 60, 100 and 140 fish m^{-1} and fish fed on 30% crude protein at 3% of the total biomass. The final body weight for the three stocking rate were 163, 110 and 87 g, respectively, feed conversion ratios were, 1:2.1, 1:2.3 and 1:2.4 and the total production was 14.49, 15.64 and 15.02 kg/m^3/year for the three stocking rates, 60, 100 and 140 fish/m^3, respectively. Economic efficiency of the results indicated that the total costs of the three treatments were 6725, 7751 and

8025 LE and the returns were 4362, 4523 and 4920 LE/tank/cycle. Based on this economical analysis production of this system considered not economic, therefore this farm tended to produce tilapia fry in the present time[1].

Greenhouse culture:

Aquaculture in greenhouse ponds was established in some hatcheries and farms in the last year. In this system of production the grow-out season could be extended and two production cycles could be obtained per year and fish production could be doubled per area unit. The hatchery of the Arab Organization for Agriculture Development located at Abbassa, Sharkia Governorate uses greenhouse concrete ponds (Fig 7) for rearing tilapia fry produced in the cold months until the beginning of grow-out season, by this system the tilapia fingerlings being available in the appropriate size and in the appropriate time for aquaculture in ponds, cages or in rice fields.

Cage culture:

Cage culture (Fig 8) represents a type of intensive system that does not require large areas of land and in most cases, necessitates lower capital investments when compared to land-based intensive farms.

There was a significant increase in number of cages where only eight cages were established in 1985 in Dameitta Governorate reaching 1542 on 1990. It was probably stimulated by modest capital investment requirements. However, their number then declined afterwards to 560 cages on 1995 having a total production volume of about 200,000 m^3 producing 1977 tons (table 4). Legislation and environmental issues as well as the conflict with other activities were behind such decline. According to GAFRD (1998) the cage culture increased gradually and reached to 1294 unit in 1998 (table, 4) representing a production volume of 285,490 m^3. These units area yielded 2855.3 tons with an average of 10 kg/m^3. In the year 2003 the total number of cages increased to more than 4000 cages (2084 in Dameitta; 1500 in Kafr El-Sheikh, and 500 in Dakahlia governorates)[2]. Tilapias are almost the only species cultured in such cages. The contribution of mullet and carp is still insignificant. Marine cages started to exist where seabream and seabass are the species of choice.

Although irrigation authorities have not encouraged cage culture in the river Nile, because of pollution and/or navigation issues, this activity is expected to greatly expand in the coastal lagoons during the next years, being monitored and controlled by local environmental departments. The government views the activity not only for food supply criteria, but also as a means of solving unemployment problems.

Table (4): Cage culture in Egyptian Governorate in the year 1998

Governorates	No. of cages	Production volume (m³)	Production (tons)
Dameitta	532	265500	2655
Kafr El-Sheikh	61	915	9.2
Beheira	237	6571	65.7
South Sinai	10	360	3.6
Menia	1	60	0.6
Sohag	50	10000	100
Kalubia	45	939	9.5
Fayoum	340	265	2.7
Asyout	14	640	6.5
Beni Sweef	4	240	2.5
Total	1294	285490	2855.3

Source: GAFRD (1998)

Feeds and feeding of caged fish:

On the basis of feed inputs, cages can be classified into three categories, as extensive, semi-intensive and intensive. In extensive cage culture, fish depends solely on available natural foods such as plankton, detritus and organisms carried in the drift. Semi-intensive culture involves the use of low protein (<10%) foodstuffs, usually produced from locally available plants or agricultural by-products, to supplement the intake of natural food. In intensive culture fish is almost dependent exclusively on external supply of complete high protein (>20%) food, usually based on fish meal (Beveridge, 1984). It includes the appropriate quantities and types of proteins, fats, carbohydrates, minerals and vitamins (New et al., 1993). In Dameitta and Kafr El-sheik governorates feeding of caged fish depending on artificial feeds beside poultry manure but the monoculture of silver carp depending on the natural food only available in the water.

1.4.4. Integrated fish farming:

In Egypt rice-fish culture is an old practice, it was traditionally followed among rice farmers in the northern part of the Nile delta. However, the results are not encouraging for several reasons, including poor preparation of rice fields for fish culture, the short period of flooding which is not long enough to promote substantial growth, the need for larger fishes to be stocked and the increasing use of pesticides in rice fields. Table (5) show the rice area integrated with fish in the different governorates.

The importance of rice-fish culture has fluctuated according to the areas put to rice cultivation. There has been a considerable expansion in rice-fish area in the 1980s with a peak in 1989, at a time when the price for rice was not favourable and new reclaimed salt-affected land was taken under cultivation with continuous flooding and fish production. This situation changed after 1989. Rice prices increased, the adoption of high-yielding varieties led to a higher productivity, and reclaimed lands were converted to rice monoculture (Halwart, 1999). Fish production from this system peaked at 28,000 tons in 1997, when only 139,2000 feddan of rice were integrated with fish. The position in 1997 was a direct result of the abandonment of the free delivery of fingerlings to farmers. Following this situation, the Ministry of Agriculture decided to restore the policy and, in the future, production is expected to increase.

Table (5): Rice-fish integration system in Egypt in the year 1998

Governorates	Area (feddan)	Production (tons)
Gharbia	26,000	1,560
Dakahlia	42,000	2,100
Dameitta	14,000	560
Kafr El-Sheikh	60,300	3,300
Beheira	51,300	3,200
Sharkia	27,000	1,200
Fayoum	8,000	320
El-Wadi El-Gadeed	5,000	200
Total	233,600	12,440

Source: GAFRD (1998)

With regard to the research scale, there were some experiments that carried out to evaluate the technical and economical feasibility of cultivating Nile tilapia (*O. niloticus*) in rice fields under the Egyptian conditions. Shaheen et al., (1959) carried out the first experiment of fish culture in rice fields in Egypt when Nile tilapia (*O. niloticus*), tilapia galilae (*Sarotherodon galilaeus*), Tilapia zilli and common carp (*Cyprinus carpio*) were grown in monoculture or polyculture. Fish production was 40 kg/ha for Nile tilapia and 69-124 kg/ha for common carp in the monoculture and 96 kg/ha in the polyculture of 60% common carp and 40% Nile tilapia. In subsequent work, El-Bolock and Labib (1967) cultured 20-56g common carp fingerlings in rice fields at stocking rate of 750-1250 fingerlings/ha for 2-3 months, the fish yield was about 200 kg/ha with 5-7% increase in rice yield. Sadek and Abdel-Hakim (1986) found that, when common carp fingerlings were stocked at stocking rate of 714 fish/ha, the fish yield ranged between 91.2-104 kg/ha within a growing period of 153 days, moreover, the rice crop increased by 11.4% compared with non-stocked paddies. Sadek and Moreau (1998) found that, when prawn (*Macrobrachium rosenbergii*) cultured at stocking density of 1 and 2 fish/m^2 in rice fields, the mean prawn yields in the low and high densities were 429.0 and 844.6 kg/ha, respectively after 90 days of culture however, when Nile tilapia (*O. niloticus*) was stocked with prawn at a stocking rate of 1 prawn+0.5 Nile tilapia fish/m^2 in a polyculture system, the mean prawn yield was 254 plus 754.4 kg/ha of Nile tilapia. They added that, the rice yields in the paddies with low-density prawn monoculture, high-density prawn monoculture, polyculture and the control (rice without fish) were 8806, 8722, 8605 and 7378 kg/ha, respectively.

Direct integration between animal husbandry and fish culture is not highly developed, only a limited number of fish farms integrated their production with poultry, mainly ducks. In this system the land animals are raised on balanced diets and their wastes (manure and feed wastage) are used by fish directly or indirectly (stimulate growth of planktonic and benthic organisms in the ponds) providing natural feeds for fish low in the food chain (Lin et al., 1993). The integration system increases the production of animals and decrease the cost of fish culture operations considerably, the duck droppings acting as substitute for as both supplementary feed and fertilizers which otherwise form over 60% of the input cost in fish culture (Sinha, 1986). Abdel-Hakim et al., (1999) evaluated the productive performance and economic benefit of integrated fish culture with farm animals. In that experiment, the polyculture of Nile tilapia , blue tilapia and common carp were stocked at a stocking rate of 3000, 940 and 60 for the three fish species, respectively. The experimental ponds received the different treatments (buffalo manure; buffalo manure+supplemental feed; Duck manure and Duck manure + supplementary feed) . Results of this experiment showed that, the best economic returns was recorded for the treatment received duck manure only and this indicate the importance of this integration system between fish and farm animals to obtain more than one crop from the same unit (e.g. duck and fish).

1.5. <u>Major cultivated species:</u>

1.5.1. <u>Indigenous species:</u>

Currently, tilapia are the main cultured species mainly *Oreochromis niloticus, O. aureus and Sarotherodon galilaeus*. Although green tilapia, *Tilapia zilli* has been identified undesirable, they enter the fish pond adventitiously in large numbers especially wherever the control systems for water inlets and outlets are not appropriate. Mullets especially grey mullet, *Mugil cephalus* are among the major cultured fish species in the early practices of aquaculture. That is mainly because of their high marketability. In addition, fry could reach marketable size in one growing season. However, there was normally shortage in their natural supply required for aquaculture. In that respect, *Mugil capito* which are considered the following important species in the mullet group were normally collected in numbers enough to make up the shortage of grey mullet fry. However, a nursing season was required to grow them up to market size.

As aquaculture sector grew and the area under culture has doubled, the demand for the mullet fry especially grey mullet began to exceed their supply. Similarly, as management practices are continuously developing, other species started to contribute more in culture systems; tilapias began to have a major role in Egyptian aquaculture (El-Gamal, 1997).

Accidental entry of some other fish species cannot be ignored. African catfish, *Clarias lazera* and Nile perch, *Lates niloticus* is an examples for that group. Because their predatory behaviour, these species may have an impact on fish production in fish ponds especially when they exist in high density and/or large size. However, there is a preliminary interest in culturing both fish species.

Because of the high marketability of some marine fish species, especially for exportation, they started to attract more attention. European seabass, *Dicentrachus labrax* and gilthead seabream, *Sparus auratus* are the most important species. Fry and/or fingerlings of both species collected from nature are still the major source of their culture. Expansion of their culture will be dependent on their seed production via hatcheries which still at the experimental stage.

1.5.2. <u>Introduced species:</u>

On 1934 common carp, *Cyprinus carpio* were introduced from Indonesia, their mirror carp strain were introduced in 1949 from France. Their natural spawning was practiced in few research stations. Along with the construction of fish hatcheries starting from 1970s, more carp species, in addition to common carp were introduced. Grass carp, *ctenopharyngodon idella* were first introduced from Holland on 1977 for weed control where they were successfully reproduced. Although silver carp, *Hypophthalmichthys molitrix* and bighead carp, *Aristichthys nobilis* were previously introduced from Thailand and Japan on 1954 and 1962 respectively. However, their contribution to aquaculture was not significant until fish hatcheries have been constructed and more introduction took place on early 1980s. Currently, carp species are contributing significantly in aquaculture especially in governmental fish farms. Fingerlings of common carp are the species stocked in rice fields. Fingerlings of grass carp are annually stocked in canals and drains starting from 1990 for weed control. Red tilapia hybrids were also introduced targeting better utilization of saline waters (El-Gamal, 1997).

The last carp species introduced on 1993 was the snail carp, *Mylopharyngodon piceus* for snail control in fish culture habitat. Studies are currently conducted at the Central Laboratory for Aquaculture Research at Abbassa to investigate their food habits and their possible effects on the ecosystem and also Garrah (2001) studied factors affecting seed production of black carp.

Freshwater prawn, *Macrobrachium rosenbergii* were also introduced from Malaysia and from Thailand in 1980s where their hatching was practiced and their seed became available for grow-out either in monoculture or in polyculture with some fish species.

1.6. Services for aquaculture (production inputs):

1.6.1. Fish hatcheries:

In order to support the needs of the growing fish farming industry, governmental freshwater fish hatcheries have been established starting at early 1980s. More hatcheries have been constructed since then reaching fourteen state hatcheries producing about 95% of the total fingerlings produced in the country. Such hatcheries are well distributed to provide their production of fingerlings to fish farms, rice fields and natural waters. Total numbers of fry produced was 27 millions on 1982 (El-Gamal, 1997) reaching 406 million on 2001 (GAFRD 2001).

Freshwater fish hatcheries:

Freshwater fish hatcheries have the lead production statistics where carp (especially common carp) are the major group produced. As the numbers of hatcheries increased and the real requirements of fish farming industry became clear, the mode of production has slightly changed. However, common carp still represents 62% of the total number produced during 1995 season where rice fields are the major user of their fingerlings. A significant increase in the production of grass carp fingerlings (23.3%) upon the demand of the Ministry of Public Work and Water Resource to be stocked in water canals for the control of aquatic plants. As presented in Table (6), tilapia fingerlings are not yet produced at governmental hatcheries in sufficient numbers needed for fish farms and cages. According to GAFRD (2001) tilapia fry represents 35.23% and common carp 40.32% of the total fry produced from both governmental and private hatcheries (table, 6).

In regard to the private hatcheries, although their total production of fingerlings is only 17.5 million during 1995 which only represents about 5% of numbers produced at governmental hatcheries. However, their mode of production is very different where tilapia comprised 94.3% of fingerlings produced (16.5 millions) which has promoting affect on tilapia culture. In other words, although private hatcheries produce only about 5% of total fingerlings, about 43% of the overall tilapia fingerlings come form private hatcheries. This situation became even more pronounced by 1998, when many small and medium-size hatcheries were producing all-male tilapia fingerlings. Twenty private hatcheries produced 32 million tilapia fingerlings, while the 14 governmental hatcheries provided 18 million. Today, there were 235 private hatcheries at Kafr El-Sheikh Governorate only[(1)]. These hatcheries produced 600 million mono sex tilapia fry/year[(1)]. As a result of the increasing of mono sex tilapia fry hatcheries at Kafr El-Sheikh, price of fry (thousand) decreased from 110 LE at the year 1991 to 25 LE at 2003[1]. However, total tilapia fingerlings are not yet produced at the proper time in sufficient numbers needed for fish farms and cages.

Marine fish hatcheries:

In order to develop marine aquaculture, there are two governmental hatcheries which are in their early stages. A finfish hatchery is owned by GAFRD at Abu Telaat, west Alexandria. This hatchery was constructed under a World bank loan to the Maryut Fish Farming Support Project, and was originally established as an experimental mullet hatchery. The unit comprises algal production, rotifer production and rearing tanks. A feed mill for production of juvenile feeds was installed, but does not operate due to lack of spare parts. The hatchery cannot feed beyond age 2 months, and is therefore forced to sell output at an age when mortalities in transport and stocking may be unacceptably high. Capacity of production is about 2 million fry per year. Production in 2000 was 50,000 seabass and seabream. Also, there are few number of private hatcheries, El Wafaa hatchery located just North of Ismailia, it was constructed in 1998, with a capacity for 2.5 million shrimp post larvae, and 500,000 each of seabass and seabream. Haraz hatchery is located north of Ismailia and was constructed in 1999 and 2000, with production capacity of 1 million shrimp post larvae, 100,000 seabass and 100,000 sole fry in 14 rearing tanks. Recently, a new shrimp project has started in Sinai and this includes a hatchery for production of around 200 million of *P. semisulcatus*. With respect to the research hatcheries, Suez Canal University operate a marine fish hatchery for research and training purposes at El-Arish. For a period it was supplying fry to commercial farmers, but this practice has since stopped (in 1998). A small research hatchery for shrimp is operated by the Institute of Oceanography, at Qait Bay, Alexandria.

Table (6): Fry and fingerlings production from fish hatcheries in Egypt in 2001 (Freshwater and marine water fish)

	Freshwater Hatcheries Number (million)							Total
	Common carp	Silver carp	Bighead carp	Grass carp	Black carp	Tilapia	Freshwater prawn	
Governmental	164	17.75	17.75	61.0	2.5	42.0	0.4	305.4
Private	0	0	0	0	0	101.3	0	101.3
Total	164	17.75	17.75	61.0	2.5	143.3	0.4	406.7

	Marine Hatcheries Number (million)					Total
	Seabream	Seabass	Red tilapia	Sole	Shrimp	
Governmental	0.75	0.75	2.0	0	2.5	6.00
Private	1.50	1.50	0.0	0.1	1.65	4.75
Total	2.25	2.25	2.0	0.1	4.15	10.75

Source: GAFRD (2001)

Collecting stations:

There are several collecting stations located in 7 governorates sited around the coast where wild caught fingerlings are collected for distribution. In 1998, a total number of 129.5 million were collected, of which mullets are the dominant species (92.2%); the remainder being seabass and seabream. Harvesting and distribution of wild-caught fingerlings are carried out and supervised by and/or under the control of the GAFRD. While subject to seasonal fluctuation, the yields have ranged from 95.9 million (1993/1994) to 148.4 million (1989/1990) (Megapesca, 2001).

Availability of fingerlings:

There is surplus of availability of fingerlings for few fish species required for aquaculture development. Common carp is an example. Hatchery activities and experience gained in the technology of their spawning supported their availability. Fingerlings of Chinese carp are normally available. However, the production of grass carp fingerlings started to dominate over silver carp and bighead carp due to contracting between GFARD and the Ministry of Public Work and Water Resources for the supply of grass carp fingerlings for weed control.

Because most of fingerlings needed for fish farms are obtained from hatcheries and collecting stations, therefore, at any time, with no notice, they supply of fry to a farm could be interrupted. This risk increases with fingerlings collected from natural resources. Therefore, it will be safer when the farmer can produce his own fingerlings. This may be possible with some species such as tilapia and common carp.

Production of monosex fry:

Tilapias (*Oreochromis, Sarotherdon* and *Tilapia* spp.) are a group of fishes of major economic importance in tropical and subtropical countries, but their uncontrolled and prolific breeding at a small size in mixed sex culture constitutes a serried constraint on their efficient production. Early sexual maturation resulting in unwanted reproduction and overcrowding has long been accepted as a major limitation in the culture of most tilapia species, particularly the commonly cultured *Oreochromis niloticus* and *O. mossambicus*. This unwanted reproduction generally results in suppression of growth and reduction in yields in cultured populations. The females continue to spawn at frequent intervals, even if the eggs are not fertilized. This, result in diverting the energy from growth to egg production and consequently reduced weight gain. In a mixed population, when eggs are fertilized and develop, the females do not feed during the mouth incubation and brooding period, which is a considerable drain on body reserves. Numerous solutions to this problem (the unwanted reproduction) have been proposed including manual sexing and separation of the sexes, culture in cages, controlled use of predator species, production of monosex hybrids, and direct hormonal sex reversal (Mair and Little, 1991).

During the last few years many of tilapia hatcheries that produces monosex were established. One of these hatcheries is belonging to the Arab Organization for Agriculture Development located at Abbassa, Sharkia Governorate (Fig 9). In that hatchery, 10 million all-male tilapia fry produced annually. Most other hatcheries (235 private hatcheries which produce 600 million fry/year) are established at Kafr El-Sheikh Governorate which is now considered one of the most important governorates in fish production.

Today, Egypt has legal limits the use of growth promoting hormones such as 17 α-methyltestosterone for sex reversal fish. There are other safer techniques for sex reversal which are not applied in Egypt. Induction of androgenetic diploid, one of these techniques that produced YY males which used as broodstock for the production of XY all male fry. Also, induction of triploidy considered as a good method for the solving the unwanted reproduction of Nile tilapia (Soltan et al., 1999).

1.6.2. Fish feed and fertilizers:

Manure (especially chicken manure) and chemical fertilizers are used in extensive and semi-intensive aquaculture. Manure stimulates both primary and secondary productivity and it may be more available and cheaper than formulated diets (Green, 1992) . Artificial feed often represents 60% or more of the total production costs. Therefore fertilization of fish ponds decrease the costs of feeding. For semi-intensive aquaculture, supplementary feeds are used. Traditional pond fertilization in Egypt was the addition of 6 kg urea+12 kg triple superphosphate + 24 kg chicken litter/feddan/week, respectively (Shaker et al., 2002).

Originally, pelleted cattle feed, cottonseed oil cake, wheat and rice bran were the feed ingredients used in fish farms. The production and use of pelleted feed is relatively new. Most of fish feed produced locally are of the supplemental type. Quantities of fish feeds are so far enough for present situation. Eventhough, the production of existing feed mills could be doubled. Feed mills were established by GAFRD.

Because of the cost, fish feed of 17-25% protein of sinking type pellets and the higher protein feed could be produced upon request. About 20,000 tons of specialized fish feed are currently produced. Extruders do exist in some private feed mills for the production of floating pellets. Besides, some of livestock and poultry feed mills have also set aside production lines for feed. However, none of the feed mills is capable for producing the marine fish or shrimp feed with the international level. Therefore, some types of fish and shrimp feed is imported from Belgium, United States and Japan for the requirement of early stages of marine hatcheries (El-Gamal, 1997).

Higher quality fish feed is now available from a national source. Zoocontrol at 6th October city has installed a modern feed mill with technical capacity for manufacture of most specification of fish feed. The factory has only been for a few months, also so far uptake by the sector is rather limited. The reason for the lack of adequate feeding is poor awareness amongst farmers of the nutritional needs of fish. Many farmers appear not to discriminate the basis of feed quality, preferring to use the cheapest consumable materials. There is a need to demonstrate and extended the use of properly formulated feeds within the sector.

However, ultimately, the apparent lack of poor quality feeds is not considered to be a constraint. Proper feeds are not used because present aquaculture production systems (with forced use of low value species due to lack of fish fry) do not make it economic to do otherwise. If the fry requirements of farmers can be met, they will be forced by competition within the market to optimize their production system, and feeding practices will be modified accordingly.

In general, the existing infrastructure for fish feed production are not fully utilized and are capable to support the growing industry to certain extent. Moreover, availability of organic manure especially chicken is sufficient for industry. Also the production of inorganic fertilizers is carried out at several factories nation wide.

1.7. Status of aquaculture research:

The aquaculture strategy has called for establishing a core central research management system that would encompass the efforts of the various institutions. This improve coordination and avoid unnecessary duplication of research efforts (AST 1988 and 1989).

In Egypt, research in the field of aquaculture is being carried out at several research organizations; The institute of Oceanography and Fisheries (IOF), The Central Laboratory for Aquaculture Research (CLAR), Fishery Management Center of Lake Nasser Development Authority, and Fish Research Center of Suez Canal University. Research on areas directly or indirectly related to aquaculture is being also conducted at The National Water Research Center of the Ministry of Public Work and Water Resources and at The National Research Center of The Academy of Science and Technology. Universities and some other institutes are also involved in research related to aquaculture.

The current cooperation among institutes is not at the appropriate level. However, this cooperation among institutes could be improved which will lead to complement resources available and improve the quality of research.

Research in aquaculture is actively conducted in most of aquaculture areas. Because of the limitation of facilities, universities are normally involved in basic research related to aquaculture whereas applied research are currently conducted in research institutes depending on available facilities. The overall target is to increase fish production through management practices as well as working on problems facing aquaculture development. Although some research projects have little practical implications, most of research projects carried out with main objective of increasing the productivity of fish per unit of land and water. To achieve that, research have been carried out in different directions. Pond dynamics, nutritional requirements, strain evaluation and selection, control of pollution, fish diseases, fish habitats, hatchery technology are all examples of areas investigated.

During the last few years, significant achievements were reached especially increasing the productivity of unit of land and water. Within Pond Dynamic/ Aquaculture (CRSP). Close to five tons of tilapia per hectare were obtained under different management practices in monoculture system (Green et al., 1995). The production of tilapia spawning was addressed in the same project where mass production of tilapia fingerlings achieved a production of about one million of fry were produced from 1000 m^2 of earthen ponds within 5-month growing season. Technology of spawning of African catfish was also investigated with successful achievements in their hatching and nursing. Encouraging research approach has been attempted in the area of marine aquaculture. There is a need to establish better organized aquaculture research facilities. The communication between concerned organization in the field of aquaculture need to be strengthened regardless their affiliation.

1.8. Legal aspects of aquaculture development:

Government policy restricts aquaculture development to land not suitable for agriculture. Aquaculture is often a transitional activity, as part of land reclamation programmes. Water use for aquaculture is also restricted to irrigation drainage water of variable salinity, and water drawn from coastal and inland lakes. Use of water from the Nile and from irrigation canals for fish farming is prohibited.

Presidential decree 90/1983

The decree forms the General Authority for Fisheries Resources Development (GAFRD) under the Ministry of Agriculture and Land Reclamation.

Presidential decree 465/1983

The decree describes powers and duties of GAFRD, including the right to lease all lands within 200 m of shorelines for aquaculture and fisheries activity.

Law No. 124 on Fisheries: This represents the main law on fisheries in Egypt. The key sections relating to aquaculture are:

Article 19: It is prohibited to gather, transfer or possess fish fry from the sea or lakes or other water bodies, without the written consent of the GAFRD.
Article 47: If the period of aquaculture lease is to be less than five years, then priority should be given to public authorities, public sector companies and cooperatives.
Article 48: It is forbidden to construct fish farms except on infertile lands which are not suitable for agriculture, and where the water supply comes from drains and lakes, and not from irrigation (fresh) water. Governmental hatcheries are except from this rule. To obtain a license for fish farm, formal agreement must be obtained from the Ministry of Agriculture, which is issued after obtaining permission from the Ministry of Irrigation, which will specify the volume of water available, its source, inlet size and mechanism of drainage.
Article 49: Fish farming areas will be declared by the decision of Ministry of Agriculture. The Chairman of GAFRD has issued two such decisions:
Article 50: Except for irrigation canals, it is prohibited to cut or spray any water weeds specified by decree of GAFRD.

Enforcement of the legislation is the responsibility of the Military force for marine and related affairs (on the seas) and the police force for inland water and fisheries affairs (the water police).

2. Constraints for aquaculture development in Egypt:

Aquaculture as any other agricultural activity, is affected by different factors that enhance or inhibit its development. The factors are of a technical, economical, legislative or institutional nature. The severity of the different constraints encountered explains the gap seen between production and production capacity. Nour (2000), outlined the following constraints affecting the development of aquaculture in Egypt:

2. 1. Legal constraints:

1. Fish farms are limited to areas classified as waste lands not suitable for agriculture mainly because of their high salt and alkali content and poor drainage.
3. Shortage of freshwater due to the law of Ministry of Irrigation which prevents using freshwater from River Nile in aquaculture purpose.
4. 3. Prevention of cage culture in the Nile.

2. 2. Technological constrains:

a) **Dependency on wild stock sources for marine fish seeds**: for example, the limitation of wild mullet fry is affecting the stocking levels and mullet production in fish farms.

b) **Insufficient hatchery production of fish seed**: the limited availability of tilapia fingerlings of particular sizes at specific times is visibly hindering aquaculture development in Egypt.
c) **Insufficient production of specialized fish feeds**: due to the lack of raw materials and manufacturing technology specialized industrial fish feed manufactures is limited to two factories established by GAFRD and another private factory at the 6th October city. This situation increases direct production costs, which have to be countered by increased productivity.
d) **Inadequacy of project conception and design**: there is a clear need for an improved design capacity for aquaculture projects, where specialized aquaculture engineers are required; this would reduce the damaging effects of poorly designed and engineered projects on production.
e) **Competition from other sectors**: competition in coastal zone areas is evident, where other development sectors, notably tourism and industry, are challenging aquaculture for access to the coastal resource.
f) **Insufficient training**: this factor in almost farms, where there is a lack of skilled managerial and technical personnel to assist the development of fish farms and advance technological requirements.
g) **Limited capacity of scientific research for technology development**: although there are a several aquaculture research institutes in Egypt, the contribution of these institutes to real development is limited, either because of inappropriate research targets or because of the absence of effective aquaculture extension.

2.3. Financial constrains:

The increased cost of aquaculture projects, particularly those based on intensive technology, poor credit resources for aquaculture, and high interest rates on credit are some economic constraints that is facing for aquaculture development. Furthermore, many banks view aquaculture as a high-risk venture and hesitate to give credit to commercial projects. Market limitations can also be either caused by a lack of consumer preference for the product or competition from fisheries products. Export-oriented projects have experienced the problem of adapting to export markets and their associated requirements (e.g. Hazard Analysis Critical Control Point Surveillance). Balancing the difficulties of export (i.e. market knowledge) with the extra costs associated has been a serve hindrance for Egypt.

Actually obtaining the loan is not so easy, since banks require collateral that is often beyond the ability of the small farmer, a position that is exacerbated by the perceived risks of the activity. It will take time before banks appreciate that the risk of aquaculture is no higher than that of other agriculture activities.

2. 4. Security constraints:

Security is one of the most important constraints facing the development of aquaculture activity in Egypt. Fish stolling considered a main problem for many fish farms in different governorates. The police force for inland water and fisheries affairs (the water police) can decrease fish stolling and this will be encourage a new producers for working on the field of fish culture.

2. 5. Marketing constraints:

It is necessary to carryout a kind of co-operative for fish marketing system in order to insure a good profit margin for the producer to encourage them to sustain their activities. Transportation, shortage of cold storages and ice mills are the most marketing constraints which causes a wastage of 10% of fish produced (Abdel Razek and El-Dimiri (1990). In order to sell into the EU market Egyptian procedures must be able to compete with seabass and seabream produced by particularly Greek fish farmers.

2. 6. Other constraints:

1. Lack of specific aquaculture policy and legislation causes difficulties in aquaculture development, investment and obtaining resources. Overall need for a cohesive aquaculture policy, within the general development framework, is essential for future aquaculture development in Egypt. Such policies should promote aquaculture as an activity within the overall development objectives and should consist of enforceable laws and regulatory frameworks to support aquaculture and also to protect the environment.
2. There is often weak cooperation among agencies that are concerned with aquaculture, which can lead to overlap or even conflict in their duties.
3. Poor cooperation between the production and research interests, particularly for applied technology
4. Insufficient extension services for the transfer of research to field application are also worth mentioning.
5. Pollution of the drainage water with heavy metals and some pesticides that are toxic to fish and reduced the net production. Also, fish flesh contains a considerable amounts from these pollutants.
6. The bad utilization of organic fertilizers. The high rate of organic fertilization consume the dissolved oxygen available in pond water causing many problems for fish. Moreover, the inorganic fertilization causes accumulation of ammonia and nitrite to toxic limit.
7. Lack in of knowledge on the biotechnology and genetic engineering.

3. **Development prospects:**

The key factor governing prospects for expanding traditional freshwater pond culture appears to be the conflict with agricultural development (i.e. the priority allocation of land and water resources to agriculture) and the lack of integrated planning (for resource management) between the two sectors. These and other constraints, which collectively call for a shift in aquaculture development strategy.

3.1. **Production**:

Average production from ponds, excluding government freshwater fish farms, is low (about 550 kg/ha/yr). Opportunities and methods for increasing production from existing farms have been detailed in the reports of various missions and technical assistance projects. However, the short duration of land leases from GAFRD (5 years), which does not encourage capital investment; the shortage of necessary resources good quality water, and seed and feed/feed ingredients; and weak extension services have hindered progress.

A doubling or tripling of production from private pond farms can be achieved with sustainable semi-intensive systems and known technology if resource constraints are removed. Production of 11.0 tons/fed/year has been achieved by governmental farm in Manzala area, where freshwater is abundant, pond water depth is 1-1.5 m. Production could also be increased to the same level in coastal ponds, from the present average of 360 kg/fed/year, if an adequate supply of marine fish seed can be assured and water salinity can be controlled within a range of 20-35 ppt.

3.2. **Water and land resources**:

The availability of land for fish ponds is also a major constraint to the expansion of freshwater aquaculture. The total area of pond fish farms has fluctuated widely as reclaimed land was made available for aquaculture temporarily then returned to agricultural use. If unlicensed farms now operating on arable land were to be shut down, aquaculture production would drop by 75%. There are no recent estimates of potential sites (non-arable land) for fish pond development which would be available on a permanent basis, or the nature and extent of the secure water supply.

Clearly, there is need for a more thorough information base on the long-term availability of land and water resources for pond culture, and the future of coastal and inland lakes, to enable formulation of a long-term aquaculture development strategy. There is also need for close co-ordination with the Ministry of Agriculture, the Ministry of Irrigation and other government agencies involved in land use, land reclamation and management of water resources. Generally speaking, however, the potential for horizontal expansion of stand-alone freshwater pond aquaculture appears to be poor. Development efforts should be focused on (a) increasing production from existing freshwater farms with assured water supply, using efficient, moderate-input polyculture systems, (b) incorporation of freshwater aquaculture into existing farming systems, (c) more intensive use of inland water resources, and (d) development of brackishwater and marine aquaculture.

3.3. **Seed and feed resources:**

The seed supply of euryhaline and marine fish, particularly mullets, requires urgent action for a number of reasons: (a) The government wishes to eventually protect natural fry resources to revitalize capture fisheries in the coastal lakes. [Banning the collection of wild fry at present would reduce aquaculture production by 27%, not including production from stock inland waters] (b) The current supply of wild mullet fry (about 120 million/year), even if not over-estimated, is still inadequate to meet demand (about 100 million fry will be needed for stocking costal farms alone). (c) Mullets are well suited to semi-intensive culture based on enhancement of natural food production and supplementary feeding and, by virtue of their feeding habits, are admirably suited as components of polyculture systems with freshwater or marine shrimp and tilapias. (d) Expertise in hatchery production of marine finfish and shrimp is very limited in both the private and public sector.

Tilapia seed is in short supply. However, the problem can be resolved by the production of tilapia fry in many existing GAFRD carp hatcheries and by demonstrating low cost fry production systems to farmers. In addition, investment in hatcheries could be stimulated by increasing the price of marine fish and tilapia to "free market" levels.

In view of the pressing need to develop hatcheries for tilapia and marine fish and shellfish, the government has enacted a law permitting appropriation of private land for the establishment of commercial hatcheries by Government agencies and related bodies.

Aquaculture competes with agriculture for manure, but the supply of fertilizers does not pose a problem. The establishment of two feed mills by the GAFRD seems to indicate that competition with livestock for agricultural by-products has been somehow averted. Most protein in animal and fish/shrimp feeds is of plant origin as supplies of animal protein are limited and expensive. The use of animal proteins for fish feed would be, in most cases, in direct competition with its use for direct human consumption. There is need to improve the supplementary feed produced by GAFRD for freshwater fish and to prepare supplementary feeds for marine fish, based on local ingredients, at reasonable cost.

3.4. Demand for fish from aquaculture:

The rapid growth in aquaculture output would affect prices and profitability of aquaculture enterprises. In fact, as we have seen output has increased significantly, with about half of the increase in total consumption since 1994 and in per capita consumption provided by aquaculture. The balance of the increases is supplied by capture fisheries (Mediterranean and the northern lakes) and imports.

Tilapia and mullet fell in money terms, respectively by 6.7 and 3.3% per annum during the period 1996 to 1999. Also, it should be noted that retail prices (both general and food) have been rising in this period by an average of about 5.7% per year. This suggests that the real price (relative to other goods) of farmed fish have fallen by 12.4% per year in the case of tilapia and 9% per year in the case of mullet (Megapesca, 2001).

Increased production of fish from aquaculture has clearly benefited the Egyptian consumer, with falling prices stimulating consumption. All things being equal, as production develops, a further gradual and relative decline in prices can be anticipated. However, various external factors appear to operate, and in particular during 1999 and 2000 Mediterranean catches were unusually high, due to higher than average flows in the Nile. As these levels are unlikely to be sustained, and as continued population growth of 2% can be anticipated, it is likely that demand for aquaculture products will continue to increase more or less in line with growth in supplies. As prices fall, aquaculture products will compete more strongly with imports of cheap small pelagic fish, and aquaculture will serve to replace imports as a significant source.

The market is competitive, and the main route for development of production will be through improvements in efficiency, as the most efficient farms consolidate their position in the market. Thus the focus of promotion for aquaculture investment must be on the introduction of more efficient production systems. This would suggest a change of emphasis, especially in relation to tilapia, to intensification and efficiency improvements. This is especially the case given the limitations on new sites due to land and water use conflicts.

It should also be noted that the Egyptian consumers are quite specific about the species consumed. So far aquaculture production has focused on the most popular species of tilapia and mullet, which have very substantial markets (390,000 tons or 42% of all fish consumed in 2000). In this respect aquaculture development in Egypt has met exactly with market needs (Megapesca, 2001).

Development of hatchery production of seabass and seabream can be expected to increase supplies of these species, but both have very much smaller market shares (with a total supply of less than 10,000 tons, or 1 to 1.5% of the market). There is very strong evidence that increased supplies of these species to the domestic market due to loss of EU exports resulted in a price fall of 20-35%

(depending on species and grade). Here, the present prices on the domestic market can be expected to fall more rapidly in response to growth in supplies.

Without access to export markets, the introduction of hatchery production fry of these species is likely to cause prices to collapse, since the domestic market will not be able to absorb the significantly increased level of production. EU market access is therefore of vital strategic importance for the development of marine aquaculture in Egypt, and the EU health control issue is therefore one of the central policy issues to be addressed. It is highly fortuitous for the marine aquaculture sector that lake of access to EU markets has coincided with restrictions to access of fry. Otherwise many products would have lost their investment.

3.5. Marine aquaculture:

The high priority assigned by the GAFRD to the development of marine aquaculture in its current five-year plan is warranted by the obvious constraints to expanding production from freshwater aquaculture, and the keen interest of the private sector. However, development is proceeding without adequate planning. This has already lead to serious problems of water management and pollution in coastal ponds due to a faulty pond water supply and drainage system. The adoption of semi-intensive production systems in coastal pond farms is also being constrained by limited feed and seed resources, and production management expertise.

The potential for development of marine aquaculture has not been properly assessed, and economically viable production systems are yet to be identified and validated through pilot production tests. Unless this situation is remedied, there is danger that failure of poorly planned ventures will discourage future investments.

A number of opportunities for marine aquaculture have been tentatively identified by external consultants. These include: (a) potential sites for various production systems along the Red Sea coast; (b) potential for the culture and stock enhancement of Mediterranean seabass and seabream in Bardawil Lagoon and Sinai; (c) potential for development of semi-intensive marine fish farms in association with proposed channels for improving the circulation of Lake Burullus, and (d) potential sites for land-based and cage production systems in Matruh/Alamein area, and at Fanara on the Bitter Lake. Though these studies provide valuable information, they contain little data on the social and economic feasibility of the proposed production models.

Presently, marine aquaculture was established in some few sites in Egypt.

The Mussalas, Dameitta:

The Mussalas region, near Dameitta perhaps has most potential for marine aquaculture development in the short term. There are four complexes of fish farms, comprising an estimating 517 farms, with another farms (110) in preparation[1]. Total area under production may be as high as 23,000 feddan (including Howash systems). Inputs consumed are about 50 million mullet fry, plus 4 million seabream and 1 million seabass in 2000. Output is estimated to be in the region of 3,000 tons of fish per year (Megapesca, 2001).

Almost all farms are extensive polyculture ponds, using fry exclusively from wild sources. The main species are mullet (*Mugil cephalus* and *Mugil capito*), Seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). The area provides the majority of marine aquaculture production in Egypt. The two species of mullet account for 90 to 95% of output. The problems experienced by farmers in this region are:

1. Low level of technology resulting in high mortality, low yields and only marginal levels of profitability;
2. Poor and variable water quality; high salinity (up to 50 ppt due to soil conditions and high rates of evaporation); organic pollution from Lake Manzala and land drains;
3. Lack of fry to enable increase in stocking levels;
4. Use of low price and usually low quality protein feeds;
5. Presence of Tilapia zilli (which consumes feed) with efforts at control limited by poor design and construction of most ponds and;
6. High percentage of illegal farms, resulting in high uncertainty and under-investment.

There is a need to encourage farmers in this region to intensify production, use proper feeds, and manage water quality more effectively, also availability of fry considered one of the most constraints for marine aquaculture development.

North Sinai:

The Ministry of Water Resources and Irrigation is responsible for managing the development of some 28,000 feddan of land in North Sinai, to the immediate east of the Suez Canal, an area known as Sahl El-Teena. The ministry has constructed a major irrigation canal (Salam Canal) to bring Nile water to the region, with the primary objective of developing agricultural settlement. However, the area in the most North part of Sahl El-Teena (north of the main El-Arish highway) is considered to be unsuitable for agriculture, and was allocated permanently for aquaculture in 1996. Several farms leased to farmers via the Egyptian Fishing Company and GAFRD. The area has good potential for aquaculture production, but requires substantial engineering work (by GAFRD) to provide adequate seawater supplies and drainage.

One important investment is the facility at Sinai Shrimp 21. Presently this farm is 420 hectars, with plans for expansion to up to 1500 hectars in future. The farm at present comprises hatchery (capacity 80 million post-larvae per year) nursery and grow out ponds. With respect to other aquaculture activities in the area the Ministry of Irrigation leases land directly to farmers in the southern part of Sahl El-Teena. The land is intended for agricultural production (irrigated by Nile water from Salam canal). The farmers undertake to recover the land for this purpose, using fresh water from the canal to leach the soil. A grace period of four years was provided to undertake this process. However, much of the land has been sub-let and used for (unlicensed) aquaculture production, since this is one way of generating cash flow in much shorter term.

South Sinai:

Aquaculture activity in this region is limited to only 10 cages, sited in a costal lagoon, which have a total production of 30 tons of seabream. Nonetheless, the activity is expected to develop and expand once appropriate fingerlings are available.

4. <u>Development requirements:</u>

Although, there is a continuous development in the technology in some fish farms especially the governmental ones, the average production for most of the fish farms are still low and there is a space for improvement do exist. However, the potential for expanding freshwater pond aquaculture appears to be poor and efforts should be focused on increasing production from existing farms. In that regard, it is believed that where reliable supplies of good quality water can be guaranteed, a doubling or tripling of production from private pond farms can be achieved with semi-intensive systems.

4.1. Species selection:

Species composition still require some modification; more tilapia fingerlings are required to support the development especially those species cultured in different salinity systems such as mullet. Further development of aquaculture will require improvement in feed quantity and quality. Complete feed required by marine fish in intensive aquaculture is expected to be different from supplemental type feed.

The selection of fish species capable to better under different management systems is very important for the development of aquaculture. Although tilapia and mullet are the most popular species especially in the private sector, carp are currently contributing more in fish production especially in public sector and rice fields. The shortage of catfish seeds restrict their culture to wild stocks. The importance of some marine species such as seabass and seabream is related to their high marketability and exportation. Shrimp culture started to exist because of their high market price.

4. 2. Feed availability:

Although the overall existing infrastructure for feed production can support the growing aquaculture industry to certain extent. However, marine aquaculture normally require high quality feed which in turn require some ingredients that could be lacing in the local market especially high quality fish meal. Besides, specialized larval feed such as enriched live food and microencapsulated larval feed are badly needed during the larval stages whereas high mortality of larval could result of the lack of such specialized feed. Because of cost-benefit considerations, economic analysis is important in order to ensure feasibility of Mariculture projects using such expensive feed. As Mariculture is expanding, specialized fish feed will be developed once the production systems prove to be economically viable.

4.3. Availability of fingerlings:

Although, there is surplus of carp fingerlings, there is shortage in tilapia fingerlings. Their relative low fecundity and their seasonal spawning are not helping the hatcheries to supply the industry with the required numbers early in the growing season.

Demand of fingerlings of marine species has increased several folds within short period of time. Although attempts are being in order to secure the availability of seeds of mullet as well as other marine fish through fish hatcheries, it appears that nature will remain the main source of marine fish fingerlings for years.

4.4. Availability of human resources:

Policy support for aquaculture is very limited (for example in access to land and water resources). As a result aquaculture is a residual activity, in that aquaculture is only considered as a potential when no other uses of the resources are available. In such circumstance, any production is desirable, whether efficiency undertaken or not. In the case of marine aquaculture, the geographical range is much more limited (to coastal regions) and the activity must compete with other land uses (for example tourism). Nevertheless, throughout the sector there is marked lack of a sound business approach by participants in the sector, with many farms putting little in and getting little out, and most not understanding the need for even basic requirements like reasonable quality feed materials (Megapesca, 2001).

One of the reasons why it is difficult to break this chain is the lack of technical skills available to the sector. Although many universities offer courses in aquaculture as part of their animal production syllabus, few participants work in the sector after graduation, and it is in any case not established that the courses offer much practical value to the sector. Lack of technical skills continues to be a constraint on the sector.

4.5. Research requirements:

As the intensification trend is progressing, more polluting effects of fish farms is expected. Therefore, more research is needed to investigate the impact on the environment. Water resources authorities are claiming a polluting effect of cages in River Nile. Studying such matter will finally determine the appropriate densities of cages and remove the conflict between fish farmers and the Ministry of Public Work and Water Resources. More research are also needed on potential candidates of native fish species for aquaculture. Genetic conservation of native fish species especially Nile tilapia needed more focusing. Food safety is also and important area of research.

Generally development of aquaculture in Egypt requires:

- Encouraging fish farming development by giving security to farm projects, especially those on leased lands;
- Encouraging investment in aquaculture;
- Technical and action support for the upgrading of traditional farms;
- Providing adequate supplies of healthy fry and fingerlings, at reasonable cost;
- Improving handling and distribution of live fish;
- Support for the establishment of hatcheries for Nile tilapia;
- Production of fish feeds of improved dietary balance;
- Reducing feed costs by replacing the high price feed ingredients by low price ingredients and also incorporation of the industrial by-products in fish diets;
- Encouraging investment in aquaculture and intensive fish farming;
- Encouraging integrated forms of aquaculture.

5. Developing the existing aquaculture systems in Egypt:

5.1. Pond culture

Earthen ponds are the dominant type of fish farms that exist. The average fish production of such farms range several hundred to few thousand kilograms per hectare. There are slightly more than 20 of governmental fish farms that cover about 7000 hectare. Most of these fish farms operate for commercial production. Some of the better-designed state fish farms could be instrumental in generating much of the economic data that needed by the industry. Most of governmental fish farms are currently operating under the semi-intensive culture system where relatively high production inputs are offered (Fig 10). Consequently, average production has accordingly increased and exceeded 3 tons/feddan in such farms. Acreages of private fish farms leased from the government has declined from more than 40,000 to about 14,000 hectare on 1995 (El-Gamal, 1997).

The private sector which is rapidly growing where more interest is given to the production of highly marketable fish species such as tilapia and mullet in freshwater and seabass, seabream, and mullet in marine waters. However, fingerlings are most likely purchased from governmental hatcheries and collecting stations. Where the local market requires tilapia in size range 250-

500 g and continuous daily supply throughout the year. Therefore, this require spawning as early as possible and fry should be nursed quickly at high stocking rate with continuous supply of warm water and feeding fish during winter to reach a suitable size for early stocking in grow-out ponds. Selection the appropriate pond site, planning and constructing small ponds in addition choosing the commercial and economically fish species. Formulation of cheap diets by incorporation of the different unconventional ingredients to reduce the costs of artificial feeds as possible.

5.2. Cage culture:

There are opportunities for cage culture of fish in the Nile, irrigation canals and inland lakes. However, pollution problems due to high cage density and poor sitting, and concern about potential navigation problems on the part of the Ministry of Irrigation must be resolved if cage development is to expand again underlining the urgent need for inter-sectoral planning. Current shortages of fish seed (tilapia and mullets) and suitable pelleted feeds also need to be addressed to enable expansion of cage culture.

Productivity of the exists cages could be doubled or tripled by improving management process. The following strategies are also recommended for improving cage productivity:

- Selection of fish to suit for available food resources.
- Producing fish fingerlings in suitable time for cage culture
- Polyculture technologies which balance natural food in the ecosystem with the feeding requirements of different species.
- Improving the knowledge of locally available feed resources.

With proper planning and assured production inputs (seed and feed), cage culture could be expanded to inland water bodies (Al-Rayyan depressions and High Dam Lake). In addition, there are about 4,700 km of irrigation canals in Egypt, parts of which could be used for cage culture of fish, in co-ordination with the Ministry of Irrigation, which is already producing grass carp fingerlings in cages for stocking in canals for weed control. Also, cage culture of silver carp which depending on natural food only did not affect on ecosystem and reached to the marketable size during 6 months growing season.

Winter feeding:

Many species of warmwater fish can be overwintered in cages. Tilapia are the exception and will die as temperature decreased to about 10°C. Caged fish can be fed during the winter at a reduced feeding level. Feeding is usually most successful if done on warm, sunny afternoons. Masser (1997 b) shown that catfish can gain 10 to 20% of their body weight over the winter if fed, but feed conversion is poor (>3.0).

5.3. Aquaculture in the desert:

Aquaculture in the desert considered as a new practice established in the last years, El-Keraam Farm one of these farms that established in the desert. In that farm, underground water used firstly in tilapia ponds (brood stocks, fry and grow-out ponds) and reused for catfish ponds. Water outlet from catfish ponds reused for the vegetation purposes. Fish production in this farm reached to 50 tons/feddan/year and the water outlet from one feddan (fish culture ponds) is sufficient to irrigate 100 feddans cultivated with field crops). This is a success experiment for intensification of fish production in the wide desert, and may be encouraged and extended in new reclaimed soils to increase both crops and fish production.

5.4. Marine aquaculture:

A number of development activities need not await the formulation of a marine aquaculture development plan. Most important of these is the establishment of marine hatcheries. Other activities include improvement of locally produced feeds, addressing water salinity and quality problems in coastal farms of the Dameitta Governorate, and training programmes for fish farmers.

Culture of marine fish species in Egypt cannot develop further without new inputs of fry from hatcheries. The harvest of wild fry from the costal zones of Mediterranean (which produces an estimated 650 million fry per year) is not able to supply significantly more fry than it presently does. There is concern over the impact of this fry fishery on the wild stocks. There is also evidence of elevated levels of mortality during transport (about 57%). In the long term, this activity is not sustainable, and cannot supply the fry requirements for marine aquaculture. Prices paid by farmers for fry of seabass and seabream have risen from LE 5 to LE 2000/kg over the last 15 years and there is a clear need for hatchery production of marine fish fry to supply the grow out sector (Megapesca, 2001).

5.5. Rice-fish culture

Since rice yield is not impaired by fish culture, nor is production area lost to fish refuge and ecological conditions are favorable, concurrent rice-fish integration must be encouraged. In a field experiment, Abdel-Hakim et al., (2000 b) Stocked Nile tilapia (4.08 g) at a stocking rate of 1000 fingerlings/feddan cultivated with rice. The growing season for tilapia was 90 days. In that study they found that, the average daily weight gain ranged from 0.66 to 1.04 g with an average of 0.87g during the whole experimental period. They also added that rice-fish integration system increased the rice yield by 148 kg/feddan beside 77.9 kg fish/feddan. The rice-cultivated land in Egypt is about 1.552 million feddan/year (FAO, 1997). According to the results of this study, if we cultivate 1 million feddans only, we could get productivity about 80 thousand tons of fish beside 5% an increase in rice yield. The following strategies are also recommended for improving rice-fish integrated productivity:

1. Improving preparation process of rice fields for fish culture.
2. Supplying rice fields with carp fingerlings at suitable size in the appropriate time because the short period of growing season.
3. Supplying fish by supplemental feeding.
4. Prevents the using of pesticides or herbicides.
5. Using of moderate fertilization rates of rice fields.

6. **Fish management:**

6.1. **Culturing methods**

According to age and species we can distinguish different systems of fish culture, Monoculture (individual of the same age from the same specie), Mixed culture (individuals of different age groups from the same specie), Polyculture (individuals of the same age from several species) and mixed polyculture (individuals of different age groups from several fish species. The different types of polycultural pond stocking are adapted in accordance with the climate, quality of water supply, fertility of the pond, availability of food and fertilizer and availability of fish fry and fingerlings (Hafez, 1991).

6.1.1. **Monoculture**

As defined above, monoculture means the culture of individual of one specie from the same age, monoculture is the only method of culture used in running waster system, re-circulating system and in cages where the supply of natural food is limited. Under the conditions of pond culture with fertilization monoculture of single fish specie, the natural food available in the water column is not fully consumed by fish, therefore a combination of fish species differ in their feeding habits is preferred. Soltan (1998) fond that increasing stocking density of silver carp fingerlings in tilapia ponds increased the total fish yield.

6.1.2. **Polyculture**

The most important consideration in polyculture is the probability of increasing fish production by better utilization of natural foods. Species successfully stocked together are differ in their feeding habits and occupy different trophic niches in the pond. Tilapia species, common carp, sliver carp and grey mullet are different in their feeding habits. Table (7) indicated the influence of polyculture on fish yield in comparison with monoculture. Swick (2001) show that, the concept of 80:20 pond fish culture is to raise crops of fish in ponds where approximately 80% of the harvest weight is composed of only one feed-taking high value species with high consumer demand and approximately 20% is composed of “service species” such as filter feeders that clean the water and predaceous fishes that control wild fish and other competitors. The 80:20 system typically provides higher yield and higher profit than monoculture or with other relative densities of fish.

Polyculture of common carp (*Cyprinus carpio*) with all-male tilapias, and sometimes also with silver carp (*Hypophthalmichthys molitrix*) is a common practice in Egypt. Both tilapias and silver carp graze on algae, and thus help to maintain a balanced biological environment in which algal blooms are rare. All-male tilapias in polyculture with marine and/or fresh-water prawns (*Macrobrachium rosenberghii*), also produce a more balanced biological environment in ponds than monoculture of prawns alone (Mires, 1995).

Abdel-Hakim et al., (2001) found that, stocking of earthen ponds (2000 m^3) with 2000 tilapia + 1000 mullet + 800 eels and fed on 32% protein diets seemed to be the best in terms of ratio of returns to total costs compared to that supplemented with 20 or 44% protein diets. Edirisighe (1990) tested the suitability of common carp for inclusion in bighead carp-Nile tilapia polyculture systems in fertilized ponds. The three species combinations were used randomly at a stocking rates of 18,000 fish/ha, bighead carp:tilapia, 2:1; bighead carp:tilapia 1:2; bighead carp: common carp : tilapia, 2:3:4. Ponds were fertilized with 1,000 kg/ha/week of duck litter. At the end of the 154-day culture period, results showed that, inclusion of common carp resulted in a significant increase in growth rate of bighead carp and Nile tilapia, showing that the incorporation of a bottom-dweller was beneficial.

Table (7): Influence of polyculture on fish yield in comparison with monoculture.

	Monoculture (ton/ha)	Polyculture (common carp, tilapia, silver carp and grey mullet (ton/ha)
Fertilization, without feeding	1.2	3.0
Fertilization, with supplementary feed	3.5	9.4

Source: Shepherd and Bromage (1995)

6.2. **Fish species suitable for fish farming:**

The success of fish farms principally depended upon the cultured fishes. The best performance of fish species under one set of conditions, whether natural or in ponds, does not necessarily ensure its success under a different conditions. Shepherd and Bromage (1995) stated that over 20,000 different species of fish have been described but less than 100 are farmed commercially. To select the suitable fish species for farming, various biological and economic factors must in consideration. a) rapid growth rate; b) acceptance of food supplied to them; c) good conversion efficiency of this food; e) good tolerance of the existing limnological conditions; f) high resistance to parasite and disease; g) rapid supply of fish seed; h) high marketable value ; I) existing market for the cultured species and j) easy commercialization (fresh if possible).

Under the Egyptian conditions, with the wide range of environmental conditions that exist in the country, several types of fish are cultured. In the freshwater areas, a polyculture system of tilapia, common carp, *Cyprinus carpio*, mullets (*Mugil cephalus* and *Mugil capito*) and catfish (*Clarias lazera*) has been established (Hafez, 1991). The Chinese carps, the silver carp, *Hypophthalmicthys molitrix*, the grass carp, *Ctenopharyngodon idellus* and the bighead carp, *Aristichthys nobilis* have been introduced to the farms. Theses species were also included in the freshwater polyculture system. The occurrence of *C. lazera* and *Lates niloticus* occasionally takes place in freshwater fish ponds. The four species of tilapia which are found in aquaculture operations in Egypt are *Oreochromis niloticus, O. aureus, Sarotherodon galilaeus; Tilapia zilli and* tilapia hybrids.

El-Serafy et al., , (1993) mentioned that a polyculture combination of silver carp, common carp, bighead carp, grass carp, mullet and tilapia are successfully cultured in ponds.

In the saline areas, The grey mullets (*Mugil cephalus* and *Mugil capito*) are used predominantly with some marine species namely the seabream (*Sparus auratus*), the seabass (*Dicentrarchus labrax*), and the salt tolerant *T. zilli.* Sole (*Solea solea*) has been introduced and experimented for rearing and artificial breeding by Hamza and Zaki (1987). Recently, attention is being given to the culture of the seabream and the seabass in cages (Hamza et al., 1988).

Generally, the main cultured species are tilapias - mainly *Oreochromis niloticus* (about 35% of total aquaculture production), carps - mostly *Cyprinus carpio* (35%), mullets -mainly *Mugil ramada* and *M. cephalus* (23%), African catfish - *Clarias gariepinus* (3%), gilthead seabream - *Sparus auratus* (2%), and seabass - *Dicentrarchus labrax* (2%) (Shehadeh and Feidi, 1996).

Species suitable for cage culture

Raising fish in cages is limited to a certain period through which the fish must reach the marketable size. Fish species culture in cages must be have the following characters: a) rapid growth rate; b) tolerance of high stocking densities; c) acceptance of food supplied to them in the cages; d) good conversion efficiency of this food; e) good tolerance of the existing limnological conditions; f) high resistance to parasite and disease; g) rapid supply of fish seed; h) high marketable value I) existing market for the cultured species and j) easy commercialization (fresh if possible). Many species of fish are suitable for cage culture such as tilapia, catfish, carp and mullet. One distinct advantage in the cage culture of tilapia is that they are unable to reproduce in cages and, therefore do not overpopulate the pond. Better growth is achieved if all-male populations are stocked. Tilapia should be harvested before water temperature reaches 16°C (Masser, 1997 a). The same author showed that tilapia can be stocked in the same cage with catfish (polyculture), polycultured of tilapia and catfish will increase catfish growth because they stimulate the catfish to feed more aggressively, increasing feed consumption. In polyculture with catfish, tilapia should be stocked at rates between 1 and 3 tilapia per 10 catfish. Under the Egyptian conditions, Abdel-Hakim and Sherif (1999) showed that, tilapia could be cultured together with mullet and common carp in floating cages throughout the period from March to November. Also, Abdel-Hakim et al., (2000 a) recommended the culture of eel (*Anguilla anguilla*) with tilapia (*Oreochromis niloticus*) and mullet (*Mugil cephalus*) in cages using artificial diets containing at least 20% protein plus trash fish at a ratio of 2 to 1.

6.3. **Stocking rate:**

Growth and production of cultured fish are to a certain extent, dependent on the population density. The negative effects of higher stocking densities are the reduction of growth rate and lowering of survival rate. In fish farming practices, the best growth rate and high production are usually attained at a particular stocking density, beyond which the growth rate is considerably reduced and below which the fish do not grow as well as or better than those at the optimal stocking rate (Diana et al., 1991; Yousif, 1996 and Knud-Hansen and Kwei, 1996).

Suresh and Lin (1992) reared red tilapia with an average size of 75 g for 70 days in recirculating concrete tanks at densities of 50, 100 and 200 fish/m^3. They found that the daily weight gains were in the order of 0.77, 0.65 and 0.64 g/fish and the FCR values were 2.25, 2.57 and 2.61 in the low, medium and high stocking densities, respectively. Eid and El-Gamal (1997) studied the effect of stocking density (50, 75, 100, 125, 150 and 200 fish/m^3) on weight gain, absolute growth rate, SGR, FCR, PER and survival rate of *Oreochromis niloticus.* Fish were fed on a diet contained 30% CP twice a day at 3% of total body weight for 120 days. Maximum weight gain, survival rate and economic efficiency were obtained at 50 and 70 fish/m^3. Al-Azab (2001) reported that the final body weight of Nile tilapia *O. niloticus* fed at either 4 or 8% of total fish biomass decreased ($P<0.05$) in progressive manner with each increase in the stocking density (form 50 to 100 and 150 fish/m^3).

6.4. **Feeding of farmed fish:**

Feed costs is considered to the highest recurrent cost in aquaculture, often ranging from 30 to 60%, depending on the intensity of the operation. Any reduction in feed costs either through diet development, improved husbandry or other direct or indirect means is therefore crucial to the development and well-being of the industry (Green; 1992 and De Silva and Anderson, 1995). During the last years the increasing in price of imported fish feed ingredients (fish meal, yellow corn and soybean) subsequently followed by an increase in the price of artificial fish feeds, therefore, there were many attempts to reducing feeding costs by enhancing the natural foods available in fish ponds by fertilization and replacement of the high cost feed ingredient such as fish meal by other plant sources of protein (soybean meal) and also incorporation the industrial and agricultural by-products in fish feeds. The importance of a by-product materials as a feed ingredient in fish diets is determined by the quality, quantity and availability of its nutrients to fish.

6.4.1. Fertilization of fish ponds:

It is a common practice to fertilize ponds to stimulate the natural productivity as feed (Kund-Hansen and Batterson, 1994). Natural food represents about 20-25% of the total food required for the higher production (8-12 tons/feddan/cycle, while it represents 40-50% in the lower production (4-6 tons/feddan/cycle (Saleh, 2001). Fertilizers for fish ponds are classified as chemical fertilizers (inorganic compounds) or organic fertilizers (manures). Organic and inorganic fertilizers are often used in fish ponds to increase pond fertility consequently improve fish production. Phosphorus, nitrogen and carbon are major nutrients for production of natural food in ponds (McNabb et al., 1990). The importance of chemical fertilizers and animal manure as fish ponds inputs has long been emphasized. The chemical fertilizers stimulate the natural productivity through photosynthesis, whereas animal manure provide, upon decomposition, nutrients for both autotrophic and heterotrophs. El-Kerdawy (1996) recommended the chemical fertilization rate of 3-4 kg superphosphate and 1-2 kg urea/feddan/day. Diana and Line (1998) obtained values close to 6,600 kg ha^{-1} $year^{-1}$ of Nile tilapia with chemical fertilization alone in Thailand.

Fertilization of non-intensive, polyculture ponds usually results in great production (Green et al., 1990), Also, the same authors reported that when manure was applied at rates of 500 to 1000 kg total solids/ha/week, its costs comprised 26% to 48% of total production costs compared with the costs of feed which represents 60% or more of the total production costs.

Under the Egyptian aquaculture conditions many experiments were conducted to study the optimal fertilization rate, the most suitable fertilization regime and economic aspects of organic and inorganic pond fertilization. In this respect, Hafez and Abdel-Hakim (1998) used three fertilization rates (500, 750 and 1000 kg of duck manure) for fertilization of earthen ponds (2.5 feddans for each) stocked with silver carp, *Hypophthalmichthys molitrix*, they found that growth performance of silver carp under the here rates of manuring was highest at the low level (500 kg/ha), followed by the high level (1000 kg/ha) in a decreasing order. Also, Abdel-Maksoud el al., (1999) fertilized the earthen ponds (each 3 feddans area) stocked with tilapia and grey mullet fingerlings in polyculture system (3 tilapia: 1 mullet), fertilization rates were, 0, 7.5 and 15 kg chicken manure/pond/ day. They found that the high fertilization rate (15 kg/pond/ day) was more efficient as compared to the other fertilization rates.

6.4.2. Combined effects of fertilization and feed pellets:

Inorganic fertilizers, organic fertilizers (manure) and feed pellets are used widely in fish ponds. The effect of each of these nutrient inputs on fish production has been tested separately under a wide variety of conditions.

The use of supplemental feed in addition to fertilization has improved tilapia yields economically. The availability of many types of commercial feeds has made it even more convenient for tilapia farms to provide feed to their fish. But while feeding ensures rapid growth of fish, feed costs often demand 60 to 70% of the total cost (Brown et al., 2002). Good feeding procedures must be developed to minimize feed wastage and deterioration of water quality, Diana et al., (1994) demonstrated that when tilapia fish were fed on half ration and full ration in fertilized ponds, the yield were similar in both treatments, indicating that the feed inputs could be reduced by as much as one-half. Also, Brown et al., (2002) found that, reduction of ration to 67% of satiation had no effect on tilapia growth or yield raised in ponds fertilized with 28 kg N and 5.6 kg P ha^{-1} $week^{-1}$.

In culture conditions where some natural food is available, 3 to 5% of the total weight (biomass) of a crop is reasonable rule of thumb for providing pellet food to finfish (Avault, 1996, & Nwanna and Bolarinwa, 2001). Another feeding practice is to provide all the food the fish will consume to ensure that all individuals obtain sufficient nutrition during the grow-out period. However, this latter practice can be costly and may create water quality problems.

Hebicha and Green (1995) evaluated the economic efficiency of five production regimes of tilapia fish under the Egyptian conditions. The production systems are, 1) traditional system with mixed six (TRAD), where urea, superphosphate, chicken litter and 25% protein pelleted feed were used; 2) chemical fertilization system using monsex (CHEM); where only urea and superphosphate were applied at a nitrogen to phosphorus ratio of 4:1; 3) feed only using monosex (FEED), where 25% protein pelleted feed was used and 4) chicken litter followed by feed system with mixed sex or monosex stocking (CLFEDMS and CLFEDSR, respectively), where chicken litter was used for the first 60 days, then 25% protein pelleted feed was used. All production systems were stocked with Nile tilapia at 20,000/ha, average individual weight was 1 to 3 grams per fish. Results of that experiment showed that, the total production ranged from 7616 kg for CLFEDRS to 4159 KG for FEED and 2973 for CHEM. The highest total production, net returns and average rate of return on capital were recorded for CLFEDSR, TRAD and CLFEDMS in decreasing order. In another study, Shaker at al., (2002) studied the effect of three treatments on growth performance of mullet (*Mugil cephalus*) stocked on earthen ponds in Sahl El-Teena, North Sinai. The three treatments tested were, traditional (6 kg urea+12 kg superphosphate + 24 kg chicken litter/feddan/week), fertilization with chicken manure (440 kg for 60 days then artificial feed for 3.5 months) and artificial feed (3% of biomass), they found that the best total fish production obtained with the traditional system followed by chicken litter and the lowest fish production was recorded in artificial feeding and they also found that, the optimum economical management of mullet in earthen ponds that received the second treatment followed by traditional treatment and the artificial feed.

Generally, results of the applied experiments indicated that the combination between fertilization and pelleted feeds introduces all nutrients required for fish growth and this subsequently followed by the best growth performance and reducing feeding costs and increased the total net returns. Therefore we can recommended the application of fertilization beside the pelleted diets suggesting that this approach may be useful to farmers wishing to reduce costs without compromising sales.

6.4.3. Replacement of the high price by low price feed ingredients:

Fish meal is one of the most expensive ingredients in fish diets. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal. Of all the plant protein feedstuffs, soybean meal is considered to be the most nutritious and is used as the major protein source in many fish diets (Lovell, 1988). Growth has tended to be reduced in fish fed diets with soybean replacing all the fish meal (Mohsen and Lovell, 1990; Carter and Hauler, 2000; Elangovan and Shim, 2000; Floreto *et al.*, 2000; Soltan et al., 2001 and Abdel-Ghany 2001) and the lower growth rate may be due to reduced amino acid availability in diets with a high percentage (>50%) of soybean meal (Darbowsky *et al.*, 1989). Reasons for this decreased growth is due to the activity of protease (trypsin) inhibitors in crude or inadequately heated soybean meal (Willson and Pope, 1985). Although, soybean protein has a well-balanced amino acid profile for fish, it is low in methionine (Storebakken *et al.*, 2000). Soaking in tape water and in normal saline (0.9%), gamma irradiation and treatment under pressure completely destroyed the trypsin inhibitor and the hemagglutinin activity in soybean (Eman, 2001).

Some experiments were conducted to evaluate the effect of replacing the high price fish meal by the low price plant protein sources, Soltan et al., (2001) found that, soybean could be replace up to 25% of fish meal with slight decrease on growth performance of Nile tilapia. In another study, Abdel-Ghany (2001) found that it is feasible to use soybean meal instead of fish meal as a substitute up to 75% in a 35% protein diet for African catfish without any adverse effect on growth performance. In this respect, Omar and Nour (1986) tested twelve experimental diets containing 18, 25, 33 and 40% crude protein from a)plant protein, b) animal protein and c) a mixture of animal and plant protein, they found that, the diet containing 33% crude protein from animal source produced the optimum growth performance of common carp (*Cyprinus carpio*) and feed utilization than the other tested diets. They also added that, the mixture of animal and plant protein in the diets increased the growth performance and feed utilization more than the plant protein alone in the diets. Ogunji and Wirth (2001) tested fifteen diets were formulated to contain 33.32% dietary protein, they found that, Nile tilapia fish fed the diet contained 43% fish meal recorded the highest weight gain and specific growth rate which not significantly different when part of the fish meal was substituted with 18% soybean and 5% blood meal.

6.4.4. Incorporation of industrial and agricultural by-products in fish feeds:

In Egypt, it is commonly known that, there is an observed shortage in the traditional feedstuffs rather than the continuous increase in their prices from time to time. Also, the high costs and/or fluctuating quality of soybean meal lead to identify alternative protein sources for use in fish feed formulation. Therefore, attempts have been carried out to search for alternative untraditional low price by-products which could be used in fish diets. Hassanen (1991) demonstrated that, the Nile catfish (*Clarias lazera*) was able to utilize a diet containing 66% unconventional protein supplement (tomato, brewers dried grain and bean haulms). Soltan (2002) found that replacement of soybean meal by tomato by-product meal up to 50% in tilapia diet did not affect fish body weight, body length, weight gain, specific growth rate, feed intake, feed conversion ratio and protein efficiency ratio and reduces feed costs by 10.93%.

Saad (1998) found that, replacement of soybean by tomato by-product meal up to 88.9% increased the final body weight of Nile tilapia fry while the complete replacement decreased the final body weight. Also, he found that the higher weight gain was obtained for fish fed the diet contained 20% (substitution level of 88.8%) tomato waste meal with soybean meal followed by fish fed the diet contained 10% (substitution level of 44.4%) tomato waste meal with soybean meal followed by fish fed diet contained 10% (substitution level of 44.4%) tomato waste meal with cotton seed meal and these diets gained higher weight gain compared with fish fed the control diet (containing soybean meal only).

Ghazalah et al., (2002) tested another industrial and agricultural by-products, date-stone and potato by-product meals, they found that date-stone meal could be utilized by tilapia safely and efficiency as alternative energy instead of 25% and no more of yellow corn energy. While, potato by-product meal as alternative energy one could be used up to 50%, depending upon the economical conditions, without adverse effect on the performance of tilapia, *O. niloticus* diets and their utilization of different nutrients. Also, Soltan (2002) found that replacing of yellow corn by potato by-product in tilapia diets up to 40% did not significantly affect all growth performance and feed utilization and reduces feed costs by 7.53%.

From the results outlined above we can concluded the possibility of replacing the high price feed ingredients by the low price industrial and agricultural by-products to reduce feeding costs of fish and then decreased the production inputs because fish feeding represents more than 60% of the production costs.

6.5. Feeding rate:

Determination of the optimum feeding level for maintenance requirements and maximum growth may help in saving feed or increasing fish growth rate and hence increasing the farm profitability (El-Dahhar, 1994). An optimum ration which gives the best growth and feed conversion ratio. Such a ration, if properly dispensed well result in minimum wastage and minimal deterioration of the water quality. Underfeeding results in poor growth and production and overfeeding results in wastage and water quality deterioration (De Silva and Anderson, 1995).

Feeding rate is normally calculated as a percentage of the total fish biomass. This percentage to be fed is not fixed but decreased as the biomass or age increased (Tables 8, 9 and 10) but absolute amount of feed increased, therefore, there will be an optimum feeding rate dependent on feed type. Also, temperature greatly affect feed intake (Ross and Jauncey, 1981). Hepher et al., (1983) showed that at lower temperature with higher protein intake, feed efficiency of tilapia decreased and with low protein it increased. Hepher (1988) reported that at lower temperature the requirements for both maintenance and growth are lower and so the increase in temperature may affect these two functions differently. Ross and Jauncey (1981) obtained the maximum daily feed intake levels for hybrid tilapia (*O. niloticus* × *O. aureus*) reared at different temperatures as 8.5%, 6.6% and 4.4% at 30°C, 25°C and 20°C for 30 g body fish per day, respectively.

Omar (1990) studied the effect of different feeding rates (0, 2, 4, 6, 8 and 10% of body weight) on growth performance and feed utilization of *Tilapia zillii* fingerlings (2g/fish) for 10 weeks. The fish were fed a pelleted diet containing 30% crude protein three times daily and 6 days a week. Results obtained showed that increasing the level of feeding significantly ($P<0.01$) increased body weight gain and specific growth rate. Feed utilization and protein efficiency ratio were greatly improved by increasing the feeding rate from 2 to 4% of fish weight. The author suggested a daily feeding rate ranged between 4 to 6% of *Tilapia zillii* body weight.

Table (8): Feeding rate for tilapia with commercial pellets

Fish size (g)	Feeding rate (percent biomass/day)
<10	9-7
10-40	8-6
40-100	7-5
>100	5-3

Source: New (1987)

Table (9): Feeding rates for channel catfish fed on floating feed.

Fish size (g)	Percent biomass to be fed daily at various temperatures (°C)					
	15°C	18°C	21°C	24°C	27°C	30°C
4.4	2.0	2.5	3.1	3.5	4.0	4.4
10.5	1.7	2.2	2.7	3.1	3.5	3.9
20.5	1.5	2.0	2.4	2.7	3.1	3.4
35.4	1.4	1.8	2.1	2.5	2.8	3.1
56.2	1.2	1.6	1.9	2.2	2.5	2.8
83.9	1.1	1.4	1.7	2.0	2.3	2.5
163.9	0.9	1.2	1.4	1.7	1.9	2.1
283.2	0.8	1.0	1.2	1.4	1.5	1.7
449.7	0.6	0.8	1.0	1.1	1.3	1.4
553.1	0.6	0.7	0.9	1.0	1.1	1.3

Source: Foltz (1982)

Table (10): Experimental feeding guide for carp

Fish size (g)	Temperature (°C)				
	<17°C	17-20°C	20-23°C	23-26°C	>26°C
<5.0	6	7	9	12	19
5-20	5.1	6	5	4	3
220-50	4	5	6	8	11
50-100	3	4	5	6	8
100-300	2	3	4	5	6
300-1000	1.5	2	3	4	5

Source: New (1987)

El-Dahhar (1993) used two diets containing 35 and 40% crude protein for feeding Nile tilapia fry and fingerlings, respectively. Seven feeding rates ranged from 3 to 15% of body weight were used for feeding fry, while five feeding rates ranged from 2 to 6% were used for feeding fingerlings. He showed that increasing the feeding rate improved weight gain of both fry and fingerlings. Al-Azab (2001) found that, increasing the feeding level from 4 to 8% of the total biomass of Nile tilapia reared in fiberglass tanks significantly increased body weight, body length and specific growth rate, while it significantly decreased weight gain, condition factor, feed efficiency ratio and protein efficiency ratio.

6.6. <u>Feeding frequency</u>:

Feeding frequency is important to ensure maximal feed conversion ratio and dress weight of cultured fish. Therefore an important step in the feeding strategy is to determine the optimal frequency of feeding. Of course, this will not be applicable to culture practices using demand feeders. Piper (1982) put forward basic rules for feeding:

- For optimum growth and feed conversion, each feed should ideally be 1% of the body weight. Therefore if the ration for the day is 5% of the body weight per day, fish need to be fed five times, 1% of the body weight each time.
- Higher feeding frequencies reduce starvation and stunting, thereby resulting in uniformity in size.
- Dry feeds need to be distributed more frequently than moist feeds.
- At least 90% of the presented feed should be consumed within the first 15 minutes of the feeding time.

The relationship between feeding frequency and growth rate varies between species. However, a generalization is that increased feeding frequency will not result in reduced growth rates and may result in improved growth rates. Evidence presented by Omar and Günther (1987) indicates that with increased feeding frequency for common carp, (*Cyprinus carpio* L.) specific growth rate, protein efficiency ratio and protein productive value are all increased. In that study, feeding frequency was increased from four times daily to six times daily. However, in another study, Wafa, (2002) found no differences in growth performance of Nile tilapia (*O. niloticus*) fed two or three times/day.

7. Marketing and trade patterns:

Sales and marketing characteristics vary following the type of culture and the location. If harvested and delivered to collection points, auction sale to wholesalers remains the dominant procedure, using cooperative staff for icing, sorting and weighing.

Government farms tends to auction their products well in advance of harvest, while private operators depend on daily prices and demand. Cage farms harvest on demand, usually selling direct to retail. At present, most, if not all of the aquaculture products are marketed locally.

Fish marketing is a business that is almost totally private. Fish marketing regulations are concerned mainly with the quality of the product, irrespective of whether its source is aquaculture or fisheries. Egypt also imports about 25% of the fish consumed in the country, imports being dominated by frozen pelagic fish. The main consumers of frozen products have low incomes.

Market supply and demand factors control prices and the higher value 'luxury" species, which used to be exported, now command equal or higher values to those obtained on export markets. Consequently, producers are no longer interested in tackling the demanding procedures required for export. In addition, requirements such as those demand by the EU regulations have greatly increased local preparation costs for export products. Most aquaculture products are treated by the same legislation as applied to fisheries.

7.1. Fish marketing problems in Egypt:

Fish marketing problems under the Egyptian condition can be summarized in the following:

1. Fish harvesting take place during two or three months (November, December and January) and this subsequently followed by a decrease in fish price and the net returns to fish farmer.
2. There are few cold storage and ice making plants in Egypt and this increase the post-harvest losses fish. Abdel Razek and El-Dimiri (1990) stated that more than 10% of the total fish production is lost in Egypt annually.
3. Transportation: the most common means of transporting fish from landing sites to retail markets are lorries and jeeps, most of which are not provided with refrigeration equipment. The inadequate transportation system is not a serious problems because of the fish landed are immediately disposed of as fresh fish. Those of less freshness are processed into salted and smocked fish.
4. Transport of fish from fishing grounds to landing centers takes 3-5 hours or more. Fish spoils very rapidly due to the high temperatures, but ice plants are frequently lacking (Abdel Razek and El-Dimiri, 1990).

7.2. <u>EU market access for Egyptian aquaculture products</u>:

7.2.1. <u>Compliance with health conditions:</u>

Egypt presently unable to export fishery products to European Union, since it has not yet complied with the requirements of European Council Directive 91/493/EEC in respect of "health conditions for the production and placing on the market of fishery products". Egypt lost access the EU market for fishery products in October 1998, when the EU harmonized health conditions for imported fishery products based on the requirements of the Directive. Egypt has only made slow progress in meeting these requirements (Megapesca, 2001).

The General Organization of Veterinary Services (GOVS) is nominated as the Competent Authority. In February 2001 the EU/Egypt Food Aid Counterpart funds supported a short project to initiate steps towards market access. Six weeks of Technical Assistance inputs were delivered by the project. The main outputs of the project were:

1. Two new Joint Ministerial Decrees were prepared and passed in August 2001, establishing a comprehensive legal framework for controls over hygiene and health conditions of production.
2. A new inspection system of establishments for fishery products exports was designed. This is presently being implemented by GOVS. The Ministry of Agriculture will need to prepare and submit a dossier to the European Commission.
3. A training programme was designed, and implemented by GOVS. Fifteen veterinary are now trained in basic inspectors methods.

A dossier of information will be sent to the European Commission (in 2001) requesting that Egypt be considered for exports to the EU of products from capture fisheries. On approval by the Commission, Egypt will be placed on list II (permitted to supply the EU market pending inspection by Commission Technical Services). At that point, Egypt be able to supply fishery products from marine capture fisheries (except bivalves) to the EU. Export of aquaculture products requires additional controls to be implemented (Megapesca, 2001).

7.2.2. Control and monitoring of residues in farmed fish:

In addition to the general requirements in Directive 91/493/EEC, the supply of aquaculture products to this market is subject to the requirements of additional regulations:

- **Regulation 2377/90** which harmonizes approval procedures for veterinary medicines for different applications, and establish maximum residue limits and condition for each.
- **Directive 96/23** which defines measures to monitor certain substances and residues in live animals and animal products (residue monitoring programmes).

There are three parts to the residue control system, which must be implemented in third countries:

1. Legislation for
   - system for approval of veterinary medicines and establishing Maximum Residue Limits (MRLs)
   - farm level controls on application of veterinary medicine.
2. Inspection at farm level of use of veterinary medicines
3. Implementation of residue monitoring to check that the control system achieves its objective.

In terms of legislation, farm level controls are introduced by the Joint Ministerial Decree “regarding regulations and procedures related to fish and marine products exports to the European Union countries”. This decree also specifies veterinary medicines permitted for use in aquaculture and the maximum residue levels in the final product.

The legislative framework for residue controls is therefore already in place and complies with the requirements of the EU Directives. However there is no implementation of the residue control (either by direct inspection on the farm, or of monitoring of residues in farmed fish products). There is a need for the Competent Authority (GOVS) to implement this legislation, through commencement of on-farm inspections and introduction of residue monitoring programme (possibly integrated with residue monitoring for other animal products).

However, until such time as the residue control and monitoring arrangements are approved by the Commission, the EU market will remain closed to Egyptian aquaculture products. This is clearly an issue of strategic importance to the marine aquaculture sector, since domestic markets for some of the species concerned could easily be subjected to over-supply.

7.2.3. Export establishments:

Once EU market access for Egyptian aquaculture products is secured, then producers are free to supply this market. However, in accordance with the new decree, all fish, including farmed fish, must be processed and packed in an approved establishment (which is certified by GOVES as meeting the requirements of the Decree).

At present there is only one such establishment in Egypt (Salah Company, Port Said). Clearly if the Egyptian aquaculture sector is to benefit at all from access to the EU market, there is a need for more processing and packing establishments to provide the vital distribution infrastructure required by farmers.

CONCLUSION

This review article has shown that the last decade has been an immense success story for the Egyptian aquaculture sector. Aquaculture has made a very significant impact on improving the supplies of fish for human consumption, rising from just 60,000 tons in 1992 (12.41% of supplies) to 342,864 in 2001 (33.19% of supplies to market). Per capita consumption of fish has increased as a result. Egyptian people presently eat about twice as much fish now than they did 10 years ago, and about half of the increase is due to improved supplies from aquaculture.

Most of the increase in supplies have been in terms of tilapia (with new supplies of fry derived from monosex hatcheries) and mullet (fry derived from capture fisheries). In 2000, 80% of the 101, 000 tons of mullet consumed, and 55% of the 289,000 tons of tilapia were derived from aquaculture.

There is good evidence that these production systems operate in line with market demand. Prices to consumers falling both in money and real terms, with an average real term decline in tilapia price of 12.4% per annum, and 9% for mullet, bringing the benefits of price competition to consumers.

In terms of Government policy, aquaculture provides the land and water of last resort; it is confined by law to lands which are unsuitable for any other purpose. The policy is unlikely to change in the short term; new lands for aquaculture investment are increasingly difficult to find. Water resources also restricted to agricultural purposes, therefore, aquaculture can only developed by intensification of fish production in the existing farms by encourage higher levels of stocking, feeding and improved pond management.

The scarcity of, and competition for water and land from other users, as well as rising input costs are encouraging culture intensification. The use of artificial feeds, aeration and fertilizers is increasing to semi-intensive levels. A recent trend is the development of the marine sector to culture high-value species. The availability of seed of some species such as seabass, seabream and shrimp, proximity to export markets, and the establishment of joint ventures have provided the impetus for rapid development of Mariculture. However, freshwater aquaculture development will likely be shaped by national water and land polices. The over-riding consideration is scarcity of fresh by water and land. Reduction in groundwater levels, prohibition in the use of fresh water, and competition with agriculture with agriculture, the petroleum industry and tourism are major constraints that need to be resolved to facilitate expansion of the sector.

Availability of seed and feed are crucial technological constraints to future development. The high price of feed, exacerbated by currency fluctuation and high variable costs, has raised production costs. The uptake of aquaculture is also frustrated by poor legislation, especially for environmental protection and movement of aquatic animals, as well as the bureaucratic requirements for obtaining licenses and permits. Cooperation between institutions and agencies is week. In some cases, their functions overlap or are conflicting. A widespread concern is the weakness of extension services and the slow dissemination of technology.

Most of the aquaculture produce, especially tilapia, carps and grey mullet, is consumed locally. Cultured marine species are produced for export, but the competitive and high prices obtained locally and new and more costly European Union (EU) regulations have combined to discourage exports.

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