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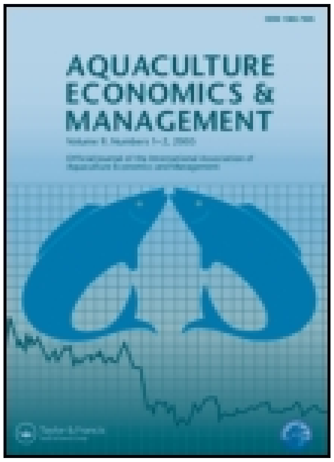

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Aquaculture in Egypt and issues for sustainable development

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Aquaculture in Egypt and Issues for Sustainable Development

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Abstract

Although aquaculture in Egypt has the potential for satisfying the increased demand for protein and has been experiencing unprecedented growth during the last decade, questions remain regarding the sustainable development of the industry. It is thus the objective of this article to review the current status and practices of the aquaculture industry in Egypt, highlighting the major issues confronting the sustainable development of the aquaculture industry.

Several issues are identified as limitations to future sustainable development, namely, production technology, fry supply, a feed industry sufficient to meet the demands of a growing aquaculture industry, and marketing and distribution systems necessary to accommodate the strong seasonal supply pattern. The article then concludes with a discussion of recommendations for alleviating these limitations.

Keywords: Aquaculture; sustainable development; Egypt

Introduction

While aquaculture in Egypt dates back to the days of the pharaohs, it is only recently that the development of the aquaculture industry is attracting the attention of public and private entities alike. Indeed, in the past decade (1991-2000), and fueled by a growing population and increasing real income, the supply of fish from aquaculture experienced a significant increase amounting to 45% of total supply - as opposed to 17% in 1991 (GAFRD 1989-2001).

However, the steady increase in demand is expected to continue, and with fisheries resources exploited beyond their maximum sustainable yield (MSY), the government of Egypt as well as developmental organizations such as the United States Agency for International Development (USAID) recognize the role of aquaculture in closing the gap between supply and demand for fish protein in Egypt. Moreover, with Egypt's trade deficit becoming a national concern, aquaculture development is regarded as having potential to contribute towards reducing the trade deficit through both import substitution and production of highly valued exportable species.

The growing importance of the aquaculture sector emphasizes the need for the sustainable development of the sector. It is the objective of this article to investigate issues pertaining to the sustainable development of the aquaculture industry in Egypt. Section 2

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reviews the current status and practices of the aquaculture industry. Section 3 discusses the major issues confronting the sustainable development of the aquaculture industry, while section 4 concludes the paper with a summary and recommendations for the sustainable development of the aquaculture sector in Egypt.

Status and practices

Production and consumption of fish products

Fish production in Egypt relies on multiple resources, which are classified according to location, water salinity, and closeness to coastlines (Basheer et al 1995). In Egypt, resources for fish production are marine fisheries, lakes and lagoon, the Nile River as well as irrigation and drainage canals, and aquaculture. During the last decade (1991-2000), total fish production increased by 110% to 724,000 tons. On the other hand, aquaculture production increased by 826% to 324,000 tons (GAFRD 1989-2001). Overall, the share of aquaculture production in total fish production increased from 17% in 1991 to 45% in 2000.

In spite of the significant growth in production, and to meet the growing demand for fish, net imports during the same period increased by 99% to 190,000 tons. Overall, the domestic consumption of fish products increased by 108% to 914,000 tons. The share of aquaculture in total domestic consumption increased from 14% to 36% emphasizing the importance of aquaculture development as well as its potential impact on the supply pattern of fish to the Egyptian market.

Accordingly, per capita consumption level increased from 8.5 kg/capita in 1991 to 14.2 kg/capita in 2000. However, with an expected population growth of 1.03% per annum for the period (2000-2010), an expected growth in real household income of 4% per annum for the same period, and income elasticity for fish demand of 0.6 (National Planning Institute 1988), the projected increase in domestic fish consumption is expected to continue to grow at 3.43% per annum.

Foreign trade in fish products

Egypt is a net importer of fish products. During the past decade, imports increased by 94% in quantity to 191,000 tons. Most imports are small pelagic fish such as mackerel and herring and are used in fish processing, e.g., smoking, or sold directly to consumers via private retail stores and government cooperatives. The main exporters are Norway, Holland, and the United Kingdom.

On the other hand, exports experienced strong fluctuations during the same decade ending with a 69% decline in quantity to 900 tons. Most exports are sea bream and sea bass for the European market. During the mid-nineties, the export market was seriously affected by the over supply from Italian and Greek producers resulting in plummeting prices. After mid-1998, exports lost access to the European market because of a lack of sanitary controls in compliance with the newly instituted directives of the European Union (EU).

Markets for aquaculture products

Tilapia is the most frequently consumed fish with supplies to the market reaching 289,000 tons in 2000, of which 54% came from aquaculture (with the balance from the lake fisheries, and the Nile). The second most popular fish is mullet, with supplies estimated at 101,000 tons in 2000. Aquaculture contributed an estimated 80% of the supply of mullet (GAFRD 1989-2001).

Aquaculture in Egypt exhibits a strongly seasonal pattern, due to seasonal temperature variations affecting fish growth and survival (e.g., tilapia), and due to the reliance on wild fry for marine species, which are available only on a seasonal basis (e.g., mullet). Accordingly, most of the annual production from farms (for a particular species) arrives on the market within a short period.

Most fish produced in Egypt are landed, distributed and consumed in fresh form. High value marine species (such shrimp, grouper and snapper) are mostly sold by arrangement with preferred customers (e.g., retail shops or restaurants). Lower value fish such as sardine may be sold by auction at the landing site, where they will be purchased by merchants for transporting to other population centers or to local retailers. Auctions are informal and privately organized. Large population centers possess areas dedicated to retail fish marketing. With the exception of the new El-Obour Market in Cairo, the municipally owned market facilities are rudimentary, with inadequate water supplies, poor drainage, lack of toilet facilities and limited facilities for chilling and storing fish. As a consequence quality suffers, and post-harvest losses, especially of cheaper fish are high. On the other hand, fish from inland sources (including aquaculture) were traditionally sold locally, either to local traders or retailers in the case of larger enterprises or directly to the consumer in the case of small fishermen and privately owned fish farms (El-Gayar and Goulding, 1996).

It is worthwhile noting that the increased production is showing impact on prices. During the period from 1997 to 2000, tilapia prices have fallen in real and normal terms, with an average decline of 5% to 7% per annum in money terms (MegaPesca 2001). On the other hand, coinciding with the loss of European markets, sea bream and sea bass prices experienced a 20% and a 30% decline, respectively. While sea bream prices recovered since then, sea bass prices have not.

Production technologies

Aquaculture production technologies can be broadly classified as extensive, semi-intensive, and intensive as shown in Figure 1 (El-Gayar and Goulding, 1996). Extensive culture systems are characterized by a low level of intervention, i.e., limited feeding and fertilization, low investment capital, and primitive management. Two primary forms of extensive systems are Howash (enclosure) culture and aquaculture in newly reclaimed lands. Howash are areas enclosed in low-lying grounds and are mostly located in and around the northern lakes of Egypt. In this culture system, fish are trapped during the period when the water table in the area is high. Fish are then left to grow and harvest is done when the fish reach marketable size after 1-2 years or when the water table is low. In some cases, control of stocking densities, pond fertilization and supplementary fish feeding are performed. Mullet species are most common in such systems. Production amounts vary from 150 to 750 kg/ha (El-Gayar, Sadek and Leung 1994). The other form of extensive culture relies on the utilization of newly reclaimed land for aquaculture. The primary purpose is to reduce the salinity of the reclaimed land to a level suitable for agriculture by continuous irrigation and drainage while making use of the land in aquaculture. *Mugil capito* is the preferred species for its high salinity tolerance commonly encountered in this form of aquaculture. Ponds are normally stocked during March and April and later harvested during December of the same year (International Economic Studies 1993). However, this form of aquaculture is temporary (3-4 years) and is terminated once the land is deemed suitable for agriculture.

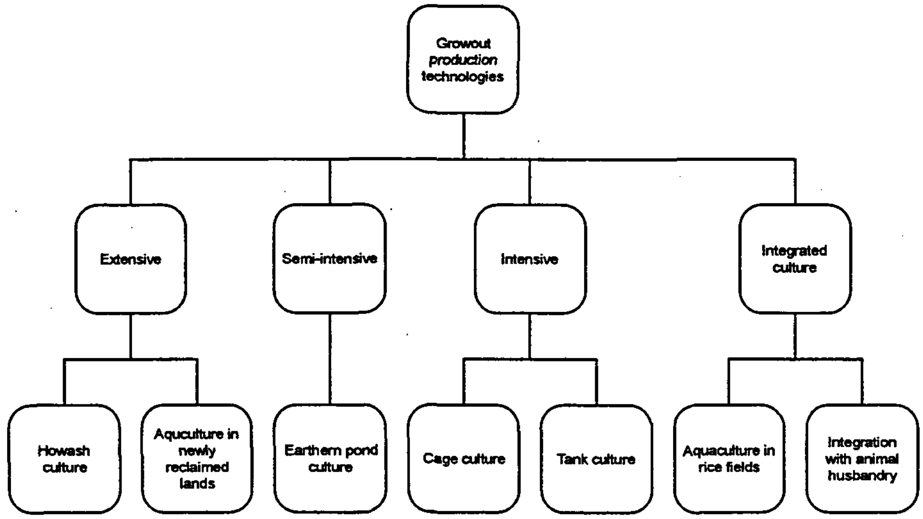

Figure 1 Growout production technologies in Egypt.

A relatively higher level of intervention and higher investment capital characterizes semi-intensive culture systems. In Egypt, the most common form of semi-intensive culture is earthen pond culture. Salinity often dictates the type of species to be cultured. For low salinity (up to 5 ppt), polyculture of tilapia, carp and mullet is most common. Otherwise, mullet species polyculture is most common, while sea bream and sea bass are used for marine culture. Management ranges from an entirely extensive approach in which nothing is added to the ponds to conventional management practices, in which ponds are fertilized and supplementary feed is administered. Production ranges from 83 to 476 kg/ha for shallow ponds and 580 to 833 kg/ha for deep ponds (National Planning Institute, 1988).

A higher level of intervention, high level of production, high production risk, and high investment capital characterize intensive culture systems. In Egypt, the most common forms of intensive culture are tank culture and cage culture. Tank culture in Egypt is practiced in concrete, fiberglass or steel tanks. Concrete ponds have been recently introduced as a result of the considerable interest in raising tilapia using intensive culture systems. Three government farms and three private farms adopted this system but half of these farms are out of business, mainly due to technical problems. Cage culture systems are used as an alternative culture system for Nile tilapia (*Oreochromis niloticus*) in the Nile and in irrigation and drainage canals. Currently, the polyculture of tilapia, common carp and gray mullet in cages is adopted by farmers in the El-Beheira governorate, approximately 100 km from Alexandria. The Ministry of Irrigation also utilizes cage culture technology to raise grass carp for release in the irrigation and drainage channels to overcome the problem of aquatic weed. In 1995, the Egyptian Fisheries Company conducted a pilot scale cage farming for sea bream. The project was followed by another similar project in 1999 by the Governorate of Mersa Matrouh, the Institute of Oceanography, and the General Authority for Fisheries Resource and Development (GAFRD 1989-2001).

In summary, aquaculture production in Egypt is mainly obtained from extensive and semi-intensive culture systems. However, average yield in Egypt is modest compared to other countries adopting similar technologies. Considerable potential for increased output exists by intensifying the production process through higher stocking levels, use of supplementary feeding, aeration, and improved pond management.

Fry production and supply

Fry are necessary inputs in any aquaculture operation. Fry are used to stock aquaculture facilities in which fertilization and feed may be administered depending on the technology involved. Besides aquaculture, fry are also used to replenish natural reservoirs. The two sources for fry supply are wild caught fry and hatchery-reared fry. By law, the GAFRD controls the supply and trade in fish fry. Specifically, the GAFRD licenses and controls of fry fishing, operates the 9 official fry collecting centers, and controls fry prices. These centers are located along the Mediterranean coast, the Red Sea coast, and the Suez Canal. In general, more than 95% of the fry caught belongs to the mullet species (*Mugil cephalus*, *M. capito*, and others) with the remaining belonging to sea bream (*Sparus auratus*), sea bass (*Dicentrarchus labrax* and *D. punctatus*), and shrimp (*Penaeus kerathurus*, *P. japonicus* and *P. semiselcatus*). However, the GAFRD control over the fry market, including prices, has also led to the creation of a black market in fry. The black market has adversely affected the aquaculture industry in several respects. First, the statistics regarding the actual number of fry caught are underestimated thereby undermining fisheries management efforts, estimates run as high as 4 to 5 times the official figures (MegaPesca 2001). Second, private sector fry traders operating illegally use very poor transportation methods thereby sustaining very high fry mortality, estimated as high as 85%. Finally, with no attempt to manage the quantities of fry collected from the wild, any increase in fry demand can ultimately result in the collapse of the fishery, with damage to both aquaculture and capture fisheries (El-Gayar and Goulding, 1996).

Fry for fresh water species are produced in hatcheries and include common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), big head carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodan idellus*), Nile tilapia (*Oreochromis niloticus*), and fresh water prawn (*Macrobrachium rosenbergii*). In 1980, the production of carp fry was 8.5 million from the only two hatcheries present at that time. Both hatcheries are government owned and produced tilapia fry in addition to carp (El-Gayar, Sadek and Leung 1994). By 1999 production of carp and tilapia fry reached 340 million fry from 14 governmental hatcheries and 36 private hatcheries. Carp and tilapia species comprised 66.2% and 33.4% of total production, respectively, while fresh water prawn comprised the remaining 0.4%. While government hatcheries produced carp and tilapia fry, private hatcheries produced only tilapia fry for supplying the surrounding fish farms. In addition to supplying governmental farms, GAFRD produced fry are used to supply private fish farms, aquaculture production in rice fields, natural reservoirs and lakes, and the Ministry of Irrigation for weed control.

On the other hand, marine water species produced in hatcheries are gray mullet (*M. cephalus*), sea bream (*S. auratus*), sea bass (*D. labrax*), and marine shrimp (*P. japonicus* and *P. semiselcatus*). There are 3 governmental hatcheries (including two hatcheries for research and training), and 3 private hatcheries. The K21 marine finfish hatchery established in 1993 by the Maryut Fish Farming Service project (MFFSP) in Alexandria, in collaboration with the Oceanic Institute of Hawaii, and funded by the United States Agency for International development (USAID) is the sole mullet hatchery in Egypt (El-Gayar, 1995). The Suez Canal University hatchery is a research and training facility in El-Arish producing *P. japonicus* and *P. semisulcatus* fry. The European Commission financed the hatchery with a total production capacity of 8 million post larvae (PL) per year. The Institute of Oceanography operates a small research hatchery in Alexandria. On the other hand, El-Wafaa is a private finfish hatchery located just north of Ismailia. The hatchery, established in 1998, has a production capacity of 2.5 million shrimp post larvae (PL) and 1 million of sea bream and sea bass.

Haraz hatchery is a smaller operation established in late 1999 with a production capacity of 1 million shrimp PL, 100,000 sea bass, and 100,000 sole fry (MegaPesca, 2001). The Sinai 21 is a shrimp farm with a hatchery that is still experimenting with shrimp hatchery and production technology. Unfortunately, a fourth private marine hatchery (Safico Shrimp farm) in Sharm El-Sheikh in Southern Sinai specializing in the production of marine shrimp is out of business.

Fertilization and feed production

Fertilizers are commonly applied in extensive and semi-intensive pond farming and to some extent in extensive aquaculture to improve the natural productivity of the pond. On the other hand, supplementary feed is used to ensure adequate growth at higher stocking densities (Pillay 1977). In Egypt, commonly used inorganic fertilizers are urea and superphosphate. These materials have low Nitrogen, Phosphorous, and/or Potassium (N-P-K) content and are used in large quantities. Popular organic fertilizers in Egypt include chicken manure, cow dung, and horse manure. Strategies for applying fertilizers differ depending on the level of technology, the soil type, the water salinity, the availability of fertilizers, and the working capital available to the farmer. El-Gayar, Sadek, and Leung (1994) indicate that about 750 kg/ha of chicken manure is applied to fishponds at the beginning of the growing season.

Supplementary feed is available in Egypt in very limited amounts. In fact, only three governmentally owned and one privately owned commercial scale factories that specialize in the production of aquaculture feed exist. The first factory was constructed by GAFRD in Barseek, Beheira, and started operation in 1989 with a production capacity of 5,000 tons/year and can reach 10,000 tons/year if operated for double shifts. The second factory was constructed by MFFSP in conjunction with the Oceanic Institute. It was financed by USAID. The factory specializes in producing high quality floating as well as sinking feed. In 1995, the factory produced 700 tons. However, the factory is currently out of operation due to the lack of spare parts. The third factory was constructed by GAFRD in Manzalla, Dakahlia and produced 1,800 tons in 1995 (GAFRD 1989-2001). On the other hand, ZooControl, the only private feed producers has installed a feedmill capable of manufacturing aquaculture specific feed.

Feed ingredients commonly used include cottonseed oil cake, wheat bran, rice bran, corn, soybean meal, fishmeal, meat meal, and shrimp meal. Most of the essential feed ingredients such as corn and fishmeal exist domestically in limited quantities and the bulk is imported. The reliance on imported ingredients can be a limiting factor to the expansion of the feed industry in Egypt due to the need for foreign exchange, and their high costs.

On the demand side, it is worthwhile noting that the use of supplementary feeding is not widely practiced by private fish farmers. Fish farmers are hesitant in administering feed due to the uncertainty regarding potential productivity improvements, the perceived high cost of feed, and working capital constraints. In effect, fish farmers still consider feed administration a risky activity.

Aquaculture organizations and legislations

In Egypt, several ministries are involved in aquaculture development activities as well as in providing extension services to the aquaculture sector as shown in Figure 2 (El-Gayar and Goulding, 1996). The General Authority for Fisheries Resources Development (GAFRD 1989-2001) operating under the Ministry of Agriculture and Land Reclamation (MOALR) is responsible for managing the entire fisheries and aquaculture sector in Egypt as designated by Law 124 for 1983 concerning fisheries management and aquaculture. The only exception is the High Dam Lake, which was managed by the Authority for High Dam Lake Development operating under the Ministry of Housing and New Communities and is currently directly managed by MOALR. GAFRD responsibilities include: issuing fishing licenses to fishermen, leasing land to the private sector to convert it to operational fish farms, supervising fishermen cooperatives, collecting statistics on fisheries and aquaculture production, providing technical support to private farmers upon request, and enforcing Law 124 of 1983 concerning fisheries management and aquaculture. In addition, GAFRD also operates 4 fish farms, 10 freshwater hatcheries, 3 nursing stations, 2 feed mills, and 9 wild fry collecting centers. The Maryut Fish Farming Service Project (MFFSP), operating under GAFRD provides basic infrastructure and aquaculture services such as feed and fry production to fish farmers in the Maryut valley near Alexandria.

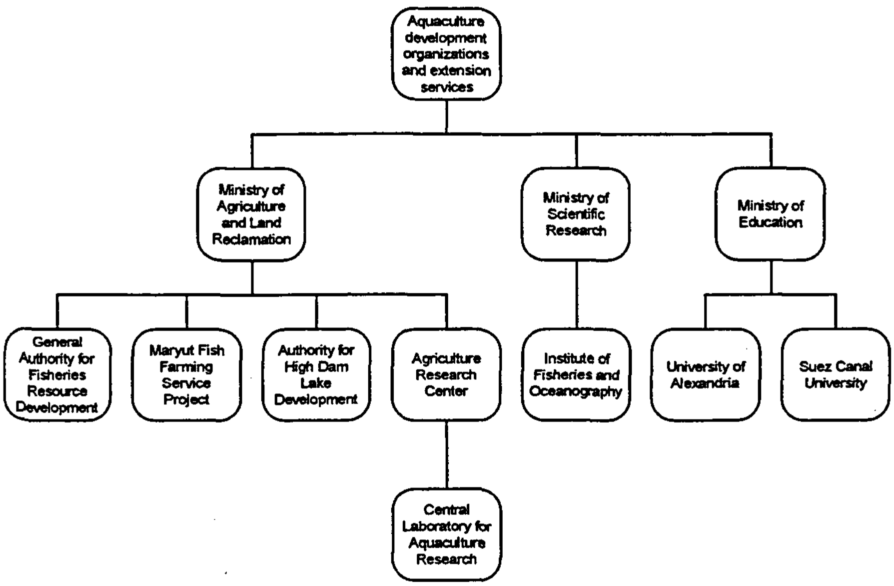

Figure 2 Aquaculture development organizations and extension services in Egypt.

The Central Laboratory for Aquaculture Research (CLAR) at Abbassa, formerly the National Aquaculture Center, was established in 1979 with financial and technical support provided by the USAID amounting to 23.7 million US dollars ($) in addition to 7 million Egyptian pounds (L.E.) contributed by MOALR. CLAR's objective is to help traditional fisheries meet the national protein requirements through research, training and extension. By June 1997, CLAR became the regional research center of the International Center for Living Aquatic Research Management (ICLARM) for Africa and West Asia. The center conducts applied aquaculture research, training and extension services.

With respect to academic institutions, the Suez Canal University offers an aquaculture program (with focus on marine aquaculture) under the Department of Animal Production, Faculty of Agriculture. The University also operates a marine shrimp hatchery in El-Arish constructed with financial support from the European Union, and a prototype feedmill specializing in the production of marine shrimp feed. The University of Alexandria houses two departments concerned with aquaculture development. The Department of Fisheries, Faculty of Agriculture, offers an under-graduate program in aquaculture, while the Department of Oceanography, Faculty of Science conducts research in oceanography, fisheries sciences and to some extent aquaculture. The Institute of Oceanography and

Fisheries operating under the jurisdiction of the Ministry of Scientific Research conducts research in fisheries biology, fishing technologies, marine chemistry, marine physics, marine geology, pollution, hydro-biology, artificial propagation, aquaculture and biochemistry.

Law number 124 issued in 1983 is the governing legislation for the fisheries and aquaculture sectors. The main articles in Law 124 pertaining to aquaculture restricted the type of water and land to be used in aquaculture (Table 1). Only brackish and marine water, and land that is deemed not suitable for agriculture can be used in aquaculture. Moreover, the establishment of fish farms is subject to approval by the Ministry of Agriculture and the Ministry of Irrigation. The latter ministry is concerned with the source and, quantity of water allowed. Fry collection and trade is only permitted with GAFRD approval. Other articles deal with reducing pollution of water resources and regulating the introduction of non-indigenous species are in Table 1.

Table 1 Articles pertaining to aquaculture development in Law 124 issued in 1983 (El-Gayar and Goulding, 1996).

Article	Description
14	It is not allowed - except by permission from GAFRD - to construct any bridges, dikes, or islands in lakes nor by its coastlines except to protect agricultural land and building from flooding, and to build fish farms.
15	It is forbidden to dispose any industrial waste, insecticides, and other poisonous and radioactive materials in the Egyptian waters.
17	It is not allowed to use or introduce non-indigenous species to Egypt for any purpose except with permission from GAFRD and after consultation with the Institute of Fisheries and Oceanography.
19	It is not allowed to collect, transport, or keep fry from the sea or lakes or any other water area except with permission from GAFRD.
20	It is not allowed for any governmental agency, organization, company, cooperative, or individuals to dry any areas within lakes until it is established by MOALR, Ministry of Irrigation, Ministry of Planning, local authorities, the Institute of Fisheries and Oceanography, and GAFRD that such areas are not suitable for aquaculture.
22	Fish resources cooperatives, fishermen, fish traders have to submit all statistical data pertaining to fishing operations, fish production, and marketing.
47	Any privileges for exploiting fisheries resources should be approved by the Minister for Agriculture and priority is given to governmental agencies, public sector companies, and fish resources cooperatives.
48	It is forbidden to construct fish farms except on areas which are deemed not suitable for agriculture. Farms should only be supplied with brackish and marine waters. It is forbidden to use fresh water in aquaculture except for governmental built hatcheries. It is not allowed to construct any fish farm except after obtaining a license from the MOALR which is issued after obtaining a permission from the Ministry of Irrigation indicating the amount of water allowed as well as water inlets and outlets of the farm.
49	Areas designated for aquaculture are to be specified by the Minister of Agriculture. Any trespassing in these areas should be removed.

Issues for sustainable development

It is evident that during the last decade, the aquaculture industry in Egypt has experienced a dramatic growth in production in absolute terms and also relative to other fish production sources. It is also evident that the aquaculture industry (in spite its successes) still suffers from serious limitation such as lack of fry, inadequate extension services, and undeveloped feed industry, to name a few. Moreover, there is the question to whether the growth of the industry is sustainable.

In that regard, we perceive sustainability from multiple perspectives. From an ecologists' perspective, a sustainable agricultural (aquacultural) system is a system with non-negative change in the stock of natural resources and environmental quality over time. Such definition has serious implication when considering fry supply, the choice of production technology and location for aquaculture production. On the other hand, from an economic perspective, a sustainable agricultural (aquacultural) is a system with a non-negative trend in total-factor social productivity (defined as the total value of all output produced by the system during one cycle, divided by the total value of all input used) (Lyman and Herdt, 1989). Finally, for the aquaculture industry to be sustainable, it has to be socially and politically acceptable. This is particularly important when considering supporting legislations and infrastructure. In summary, a sustainable aquaculture industry must be ecologically (environmentally) sound, economically viable, and socially and politically acceptable (Leung and El-Gayar, 1997).

Figure 3 depicts the issues supporting the sustainable development of the aquaculture industry. Specifically, the sustainable development of the aquaculture industry in an area involves the consideration of production technologies commensurate with the resources available and supporting legislations and infrastructure to ensure meeting social, economic and environmental objectives that must be simultaneously achieved. The following sections discuss each of these issues.

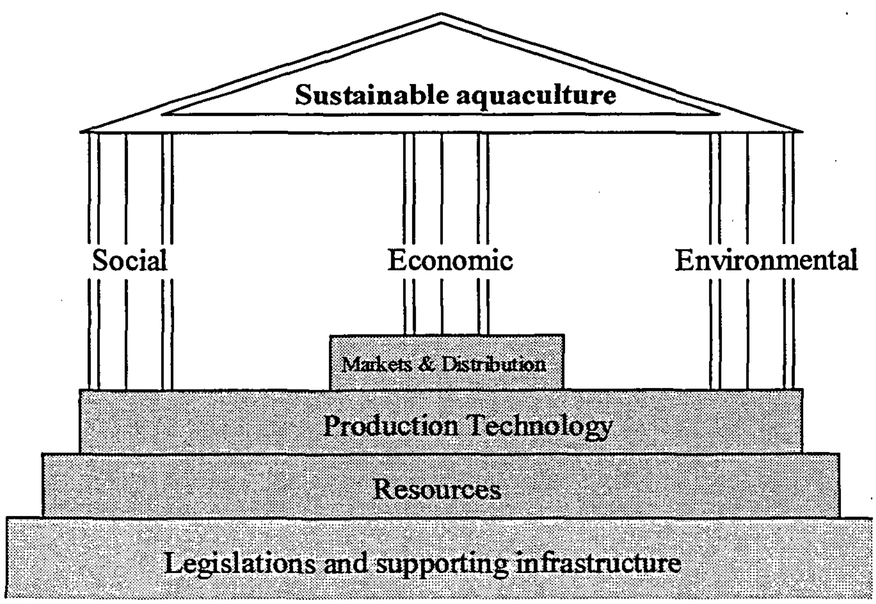

Figure 3 Issues supporting sustainable aquaculture

Resources

Resources required by the aquaculture industry can be a limiting factor to the growth the industry. However, the concern is not only limited to resource availability, but also to the preservation of the stock over time. The following sections discuss resources particularly relevant to the aquaculture industry in Egypt, namely, fry, feed, land and water, labor, and capital.

Fry

Fry supplies to the aquaculture industry in Egypt come from two sources: wild caught fry and hatchery produced fry. Each of these sources has its own issues relating to sustainability and is dealt with separately.

In recent years, wild caught fry are predominantly mullet, with a negligible quantity of sea bream, and sea bass. The market for such fry are marine and coastal aquaculture producers. The main issues surrounding wild fry supply relates to availability, transportation infrastructure and the effect on the fisheries stock.

With regard to availability, it is worthwhile noting that in interviews with marine and coastal aquaculture producers, they identify that the major constraint on their operation is the lack of access to fry. Indeed, the price for *M. cephalus* fry have steadily increased during the past five years from 10 L.E. per 1000 fry in 1996 to 20 L.E. per 1000 fry (GAFRD 1989-2001). The black market price has also experienced an increase from 70 L.E./1000 in 1996 to 150 L.E./1000 in 2001. Other marine species have also experienced a similar increase. This situation is clearly unsustainable from an economic point of view, particularly, when the prices of the end-products have actually declined during the same period. The availability of fry to private producers is further limited by the GAFRD control over the fry market with its policy favoring government-owned farms and restocking of natural reservoirs, e.g., Lake Qarun.

Related to the availability of fry to producers is the distribution of fry caught in the wild. The current transportation methods are primitive resulting in exceptionally high rates of mortality. There are no official records of actual fry mortality due to ill-equipped transportation vehicles. However, unofficial sources estimate the mortality rate as high as 82% (MegaPesca, 2001). Contributing to the transportation problem is the black market, or the illegal trade in fry resulting from the government control over the fry market. Unofficial sources estimate that the unrecorded (illegal) trade in fry is a factor of 4 to 5 times greater than the official trade. The uncertainty involved in engaging in such an illegal trade is a major deterrent for traders and producers to invest in properly equipped transportation vehicles and distribution facilities.

Also related to the availability of fry to producers is the stock of wild fry. This issue is particularly important as it affects the sustainability of the aquaculture and the fisheries sectors alike. In Egypt, the GAFRD is responsible for fisheries management including the supply of wild fry through its fry collection centers and licensing of fry traders. However, GAFRD efforts are undermined by the existence of the black market and accompanying illegal (underground) fishing and distribution of wild fry. This situation makes the development and implementation of a fisheries management policy virtually impossible, thereby threatening the sustainability of the aquaculture and fisheries sector. The stock of wild fry in general and that of *Mugiledae* species in particular are also threatened by factors outside the domain of fisheries management and GAFRD. There are factors that adversely affect the habitat of these species and their ability to breed. Examples include the reclamation of large areas of the northern lakes and pollution. As early as 1977, the area reclaimed for human purposes such as agriculture and development amounted to 60%, 29%, and 11% of the original areas for lakes Maryut, Edku, and Manazala, respectively (GAFRD 1977). Moreover, by 1988 the percentage of area lost to reclamation had increased to 62% and 30% for Edku, and Manazala, respectively (Institute of Oceanography and Fisheries, 1989). Nowadays, the area of lake Manzala, the largest and most productive lake, is one-third its original size (Bush and Sabry, 2000). On the other hand, pollution levels resulting from sewage, agricultural drainage, and industrial activities have also reached unprecedented levels (Bush and Sabry, 2000; UNDP 2001; Siam and Ghobrial, 2000).

While the wild fry supply cater predominately for marine and coastal aquaculture, hatchery produced fry cater for marine and fresh water aquaculture. In Egypt, the marine hatcheries sector is still in its infancy with total production of less than 3 million finfish and shrimp fry from all five hatcheries combined. However, given the limitations facing the supply of wild fry from the wild, the importance of marine hatcheries for the sustainability of the aquaculture industry cannot be overstated.

In spite of the new entrants into the sector, such as the Haraz hatchery, other hatcheries are facing production difficulties. The Safico shrimp farm (and hatchery), for example, is currently out of business. In that regard, we identify a number of issues pertain to the sustainable development of the marine hatchery sector in Egypt. A first issue is the availability of suitable locations with access to farms (to minimize transportation) and to sea water. For example in 1992, an initial trial for mullet fry production in the K21 hatchery relying on underground water failed. Fortunately the proximity of the hatchery to the Mediterranean Sea allowed for the pumping of seawater for use by the hatchery. The issue of finding a suitable location for a marine hatchery is further compounded by competition from other sectors (of national interest) such as tourism and out of environmental concerns. The second issue is the availability of qualified personnel. This is particularly relevant for marine hatcheries due to the sensitive nature of the operation, i.e., larvae rearing as well as the need for other supporting activities such as the production of algae, and rotifers. The third issue is the availability of juvenile feed. The lack of appropriate feed forces hatcheries to dispose of their production at an early stage when mortalities in transport and stocking are exceptionally high. This increases the overall cost to hatcheries and farmers alike.

On the other hand, fresh water hatcheries are the main source for fry for fresh water aquaculture. Both government and private hatcheries produce carp and tilapia. There are a number of issues relating to the support of fresh water hatcheries for the sustainable development of the (freshwater) aquaculture industry. First, is the ability to supply fingerlings of appropriate size (up to 0.5g) to the grow-out sector at an early stage in the season. This maximizes the grow-out season and allows farms to produce size #1 fish which command the highest price, enhancing the economic sustainability of farms. Second, is the ability to produce mono-sex fry. This controls the fecundity and improves the overall feed conversion ratio, also enhancing the economic sustainability of farms. Third, is the ability to supply tilapia species tolerant to higher salinity levels, such as the Florida hybrid red tilapia (a cross between *O .niloticus* and *T. mozambicus*). This is particularly important given the aforementioned legislation prohibiting the use of fresh water.

There are also a number of issues relating to the sustainable development of the fresh water hatchery sector itself. The first of these is the availability of suitable locations with proximity to farms and access to fresh water supply. In that respect, existing legislation prohibits the construction of fish farms and hatcheries except on infertile land, not suitable for agriculture and where the water supply comes from drains and lakes (Law # 24, article # 48). Only government hatcheries are exempt. Accordingly, all of the Nile delta where most fresh water farms exist is excluded from further horizontal expansion of fresh water hatchery production. The second issue is the availability of trained personnel.

Land and water

Land and water resources are essential to the sustainable development of the aquaculture industry. In Egypt, the issue is not as much the existence of sites suitable for aquaculture operation, as it is the legislation governing the use of land and water for aquaculture production. Unfortunately, existing legislations and policy consider aquaculture as a residual activity, that is aquaculture is allowed in an area only when no other activity is suitable. In general, marine aquaculture often conflicts with tourism and real estate developments for recreational purposes ("tourist" villages). On the other hand, fresh water aquaculture is considered to be in conflict with agriculture and is confined to areas not suitable for agriculture, and to the use of drainage water. It is also noteworthy that the quality and salinity level of the drainage water is declining as efforts to reuse the drainage water for multiple irrigation cycles are underway. This situation undermines the sustainability of existing farms.

Specific examples for the effect of existing legislations and policy on the allocation of land for aquaculture development include Sahl El-Tina, the Red Sea Aquaculture Company at Abu Zenima, and Mersa Matrouh. Sahl El-Tina (El-Tina Valley) is located to the north east of the Suez Canal and bounded by the Mediterranean Sea from the north and the main El-Arish highway from the south. The valley was recognized as unsuitable for agriculture and was permanently allocated for aquaculture. However, problems with the water supply and extremely high salinity levels, sometimes reaching 60 ppt, have undermined the operation of most farms. On the other hand, the Governorate of South Sinai halted a project for the Red Sea Aquaculture Company at Abu Zenima (on the Gulf of Suez) for the production of sea bream and sea bass, citing environmental considerations. Another example is the Governorate of Mersa Matrouh selection of 9,500 acres for aquaculture in nine different sites. While technical evaluation to assess the suitability of each site for aquaculture is currently under way, initial results indicate that many of the sites are not suitable (MegaPesca, 2001).

Feed supply

So far, the level of production technology is extensive, with minimum level of intervention including the administration of feed. Even with semi-intensive aquaculture, production levels have not yet realized their potential. One reason for the modest production is attributed to poor feeding practices and the insufficient use of quality feed. This situation undermines the economic sustainability of aquaculture farms.

Moreover, with the aforementioned existing limitations on the horizontal expansion of the aquaculture industry, the intensification of existing farms is inevitable. With increased intensification comes the need for proper farm management practices as well as the need for quality feed.

While the import of feed is theoretically possible, it increases production cost and, given the current foreign exchange crisis is clearly unsustainable. Therefore there is a strong need for specialized feedmills capable of producing aquaculture feed. While Zoocontrol is one such company recently established with production beginning in mid-2001, so far the demand by the aquaculture sector has not yet picked up. One possible factor for the slow adoption by the aquaculture industry is the lack of awareness of the benefits of feed. It is expected that any effort aimed at increasing productivity through the utilization of supplementary feed will include extension, aimed at demonstrating the benefits of feed. Once the benefits of feed are demonstrated, feed demand is expected to rise to several times the current level.

Labor

In spite of the recent growth of the aquaculture industry in Egypt, the availability of skilled labor and technical knowledge remain as an issue for the sustainable development of the industry. Although there is much public investment in education and research, it is evident that these skills are only slowly reaching the level of the practitioners. This is evidenced by the low level of production technology employed, such as stocking practices, feeding practices, and water management, to name a few. Moreover, the further development of hatcheries and intensification of the level of production technology will lead to additional demand for qualified personnel trained in the science and art of aquaculture.

Capital

Another reason for the aquaculture industry adopting extensive production systems is the lack of access to capital. To intensify production, producers need access to additional capital to support increased level of input such as fry and feed. Capital is also needed for the acquisition of equipment including aerators, pumps, and water quality kits necessary to improve the management and the control of the production operation. Moreover, the development of the hatchery sector depends on the availability of capital. Hatcheries are inherently capital intensive due to their reliance on controlled culture environments involving the use of indoor and outdoor tanks, indoor environment control, laboratory equipment, etc.

Although there exist limited sources of capital (for example the European Union's Multi-Sector Support Program (MSSP)), such initiatives need to expand to include the local banking industry through increased awareness of the viability of the aquaculture sector.

Production technology

In support of sustainable development, aquaculture production technology should not only be technically feasible and economically viable, but also environmentally and socially acceptable. A production technology that maximizes yields while degrading the environment is not sustainable. Similarly, a technology that does not harm the environment but poorly utilizes the existing resources or is not economically viable is doomed to fail.

As indicated in section 2.4, extensive and semi-intensive production systems are the prominent technologies in Egypt. While such systems are generally characterized by their limited impact on the environment (Asian Institute of Technology 1993), in Egypt, a particular form of extensive systems is an exception. Howash (enclosures) culture systems, in particular the lake-water and coastal howash, are considered harmful to the fisheries stock in the lakes and have been classified as illegal (El-Gayar, Sadek and Leung, 1994). Moreover, lake-shore howash, the third type of howash according to the classification of Tang (1979), while still legal, have generated conflict between state-licensed fish farm owners and local fisherman as noted by Bush and Sabri (2000).

Moreover, current production levels from existing systems do not exceed 1 ton/ha/yr, an order of magnitude lower than the potential of a well fertilized and managed system (Asian Institute of Technology 1993). While the current technology is still economically viable, in the long-term and with the limited land and water resources, production technology needs to improve to assure it remains an attractive option to alternative and possible competing uses of resources, such as agriculture and tourism.

Related to the production technology is water quality management and disease control. Fortunately, neither water quality management nor diseases have yet been an impediment to aquaculture development in Egypt. However, as the intensity of culture increases, the quality of water deteriorates and the stress on cultured organisms increase increasing the insusceptibility to disease. Since water and disease awareness and management are not widely practiced in Egypt, in the long run, and unless effort is made to actively support intensification efforts, water quality and disease are likely to have a detrimental effect on the sustainability of the aquaculture industry in Egypt.

Markets and distribution

The sustainable development of the aquaculture industry in particularly its economic sustainability, also hinges on the availability of markets for aquaculture products. Although the domestic demand for fisheries products fueled by a growing population is projected to increase, the market for aquaculture products is finite. In fact, local markets for mullet and tilapia show a steady fall in prices in real terms due to increased supply from aquaculture. On the other hand, prices for sea bream and sea bass, main export species, have also experienced a decline primarily due to the loss of European export markets.

Existing distribution channels are relatively short with limited geographical reach. However, with increased production, producers have to extend their distribution, and achieve a greater penetration than through existing channels. In other words, the development of an improved distribution network is essential to avoid the saturation of the market. This improvement in turn requires capital investments such as in ice plants, properly equipped distribution vehicles and market depots.

Aquaculture producers will also need to pay particular attention to product differentiation to improve the competitiveness of their products. In that respect, they have a distinct advantage over competing supplier from the fisheries sector since they not only control production, but they also have the ability to control the handling of the product from the point of production. By controlling production, aquaculture producers can control size (positively correlated to price) and timing of production. The exception to this is tilapia which is sensitive to cold winter temperatures. More importantly, delivering a high quality product through improved handling enhances the appeal of aquaculture products to niche market segments such as the hotel industry.

Quality control is also paramount for export markets. In fact, the aquaculture sector lost access to the European export markets for fishery products because of a lack of compliance with the European Union's directive on hygienic production of fishery products. While MOLAR's General Organization of Veterinary Services is setting up new systems of control and inspection of fisheries products, the initiative does not yet include the required residue control for aquaculture products.

Legislation and supporting infrastructure

The fishery and aquaculture sectors are regulated according to Law number 124 issued in 1983 and its implementation detail. However, as noted earlier, the law has serious limitations to the sustainable development of the aquaculture industry, particularly as it relates to land and water allocation (section 3.1.1) and wild fry supply and distribution (section 3.1.2).

Besides legislation, many policy-makers are not aware of the importance of aquaculture and inland fisheries for food supplies and income generation (Dar, 1999). In Egypt, MOLAR traditionally favored agriculture over aquaculture. This is not only reflected by existing laws and legislations, but also by practices such as discouraging the ownership of land and areas suitable to aquaculture. Instead, the authorities have opted to lease these areas to potential fish-farmers. Decision number 70/1986 relates to the renting of land allocated by GAFRD for the establishment of fish culture and hatcheries. According to this decision, the period of the lease is five years with 20% of the annual rent paid as a deposit, which is non-refundable in case of breach of conditions. Moreover, the GAFRD may revoke the lease with two weeks written notice, a situation that creates a great deal of uncertainty for the fish farmers and seriously affects their investment decisions and their long-term commitment to the area.

Moreover, with the exception of the recently established Egyptian Aquaculture Society (EAS), the aquaculture sector lacks proper representation within the existing institutional framework. In general, decisions over developments affecting the aquaculture sector are often made without consideration of the sector. This creates an uncertain operating environment for existing fish farmers as well as potential farmers.

The situation is further compounded by the number of ministries and government agencies involved, and with which a fish farmer or a potential farmer must deal. For example besides MOLAR, to obtain the necessary permits a prospective fish farmer needs to deal with the Ministry of Defense, the Ministry of Irrigation, the Ministry of Environmental Affairs as well as local agencies, to name a few. Other agencies include the coast guard, the police force for inland waters fisheries affairs.

Summary and recommendations

Hieroglyphs from ancient Egypt indicate that aquaculture existed in Egypt since the days of the pharaohs more than 3000 years ago. However, only recently has aquaculture been recognized as a potential source for high quality, cheap protein and for foreign exchange, needed to help balance the large trade deficit facing Egypt. While the aquaculture sector experienced an unprecedented growth during the last decade, issues remain regarding the sustainability of the sector. These issues range from the sustainable utilization of resources, the most prominent of which are fry, land and water resources, to supporting markets and distribution systems, the adoption of sustainable production technologies, and institutional constraints.

This paper emphasizes the inter-relationships among these issues. For example, the limited land and water resources (physical and self-imposed by existing legislations and policies) and the relatively low levels of production, indicate the need for farmers to intensify their production and take full advantage of new technologies and management procedures. However, with intensification come higher environmental risks from adverse effects on the environment, as well as higher production risks from higher levels of inputs, the need for water quality management, and disease control. Accordingly for this intensification to be sustainable, there is a need for it to be promoted and supported by institutional infrastructure in order to assure the deployment of sustainable technologies as well as the dissemination of related information.

The inter-related nature of these issues suggests the need for an integrated policy framework. The sections on aquaculture development of the FAO Code of Conduct for Responsible Fisheries (FAO, 1998) as well as the Holmenkollen guidelines (The Second International Symposium on Sustainable Aquaculture, 1998) for sustainable aquaculture are two such frameworks. In the case of Egypt, we summarize our recommendations as pertaining to the sustainable development of the aquaculture around three main initiatives, namely,

- Legislative support. Of particular importance is to devise comprehensive legislation, policies and the associated institutional/legal framework that explicitly recognizes aquaculture as a viable industry able to address national interests such as food security, poverty alleviation, and foreign exchange earnings.
- Promotion of sustainable technologies and the efficient use of resources. In particular, increasing the awareness of farmers and the general public to the importance of sustainable aquaculture and promoting the transfer and adoption of sustainable technologies.
- Human resource development and capacity building. In particular, education, training aimed at providing the industry with trained professionals as well as training existing farmers in the art and science of sustainable aquaculture.

Table 2 details the relationship between each of the initiatives as they pertain to the specific issues discussed in section 3.

Table 2 *Initiative supporting the sustainable development of the aquaculture industry in Egypt.*

	Legislative support	**Promotion of appropriate technologies and the efficient use of resources**	**Human resource development and capacity building**
Resources			
Fry	Permitting private, legal, but regulated trade in wild fry based on sound fisheries management practices.	Promoting hatchery technologies, particularly marine, as well as proper fry handling techniques.	Research on the genetic improvement of broodstocks and fry production techniques, e.g., mullets and sea bream. Education and training on hatchery production technologies.
Land and water	Dropping the restriction of aquaculture development to land and water not suitable for agriculture.	Improving site selection and the allocation of land through the use of appropriate technologies, e.g., Geographical Information Systems (GIS).	Research on the efficient use land and water resources, e.g., the use of drainage water and re-circulating aquaculture systems.
Feed		Increasing the awareness of feed and feeding practices	Research on the formulation of nutritionally complete feed based on local ingredients.
Labor			Enhancing existing university programs in order to meet current and future needs of the industry.
Capital	The creation of investment incentives such as tax breaks for aquaculture ventures. This mechanism is already employed for other types of investments.	Increasing the awareness regarding the importance and economic viability of the aquaculture industry to the banking industry, and potential investors.	
Production technology	Regulate the use of chemical inputs, which are hazardous to human health and the environment. Regulate the proper disposal of wastes such as sludge, effluents, and dead and diseased fish.	Intensification of production, including: 1- Efforts to improve use and selection of appropriate feed and fertilizers. 2- Effective health management practices.	Education and training supporting intensification of production. Research and development on means for intensifying production while minimizing environmental effects.
Market and distribution	Measures to comply with the EU council on hygienic production of fishery products.	The food safety of aquaculture products and efforts to maintain product quality, particularly during harvesting, processing and distribution.	Education and training supporting product quality management.
Legislations	In devising legislation, care should be given to the active participation of fish farmers, and other stakeholders.		

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