AN INDUSTRY ASSESSMENT OF TILAPIA FARMING IN EGYPT
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BACKGROUND TO THIS STUDY

This consultancy was carried out on behalf of AU-IBAR and focused on Tilapia farming industry in Egypt. The objective is to set realistic benchmarks for sustainable commercial aquaculture development in Africa from various fish culture systems in Egypt through assessment based on farm visits, interviews with those involved in the production side of the value chain, etc. The assessment is undertaken with the view of elaborating, packaging and disseminating best practices for expeditious development of the African aquaculture industry. This activity aimed at assessing factors that are integral to sustainable commercial aquaculture development including assessment of current practices and institutional settings including production technology, evaluation of existing policy and legislative frameworks for sector development, supporting institutions (e.g. hatcheries, feed supplies etc.), disease control, pollution abatement mechanism and consideration for environmental sustainability or maintenance of ecosystems integrity, enhancing public and private sector roles etc., etc.
1. INTRODUCTION

The United Nations Food and Agriculture Organization (FAO) estimates that nearly 870 million people of the 7.1 billion people in the world, that is one in eight, suffered from chronic undernourishment in 2010-2012. Almost all the hungry people, 852 million, live in developing countries, representing 15 percent of the population of developing countries (Figure 1). There are 16 million people undernourished in developed countries (FAO, 2012).

The number of hungry grew in Africa over the period, from 175 million to 239 million, with nearly 20 million added in the last few years. Nearly one in four are hungry.

Almost 4 million people across Africa depend on fisheries and aquaculture for their livelihoods, and fast-growing fish have financial benefits for farmers who can save money on labor and fish feed costs. A rise in aquaculture productivity also increases food and nutrition security by making fish available and affordable for the growing population that depends on fish and fish products (FAO, 2012).

![Number of undernourished in the developing world: observed and projected ranges compared with the World Food Summit target](http://www.fao.org/docrep/016/i3027e/i3027e00.htm)
1.1. Fish, food and nutrition security

Fish is an excellent source of high quality animal protein and essential fatty acids, especially long-chain polyunsaturated fatty acids (LCPUFA) and micronutrients, which are found at much higher level in fishes than in terrestrial animals’ source foods. Drawing on such evidence, a recent FAO–World Health Organization (WHO) expert consultation group concluded that among the general population, fish consumption is beneficial for human growth and development, while consumption of certain amount of fish (fatty fishes in particular) is associated with reduced risk of coronary heart disease and stroke (FAO–WHO, 2011). People are generally encouraged to increase consumption of fatty fishes two to three-fold in order to obtain sufficient quantities of LCPUFAs (Surette, 2008; Jenkins et al., 2009; FAO–WHO, 2011). Food-safety concerns about fish have centred on methylmercury and dioxin levels. There is no convincing evidence, however, for increased risk of heart disease linked with methylmercury while the potential cancer risks from dioxins are concluded to be well below coronary heart disease benefits associated with fish consumption (FAO–WHO, 2011).

Global wild fish catches have for some time been at or near the limits of what aquatic ecosystems can be expected to naturally provide (FAO, 2012a; United Nations Human Rights Council (UNHRC), 2012). Meeting the world’s demand for fish has thus depended on the rapid growth of aquaculture. In 2011, about 41% of fish consumed came from farming (FAO, 2012b; FAO–FISHSTAT, 2012). A growing body of research studies shows the importance of fish in the supply of not only protein but also more importantly of essential fatty acids and micronutrients (Kawarazuka & Béné, 2011). The importance of fish as a rich source of essential fats, crucial for brain development and cognition, is highlighted in the implementation of the scaling up nutrition framework and roadmap [a private and public sector and civil society partnership that seeks to better understand the crisis of under nutrition in early life (first 1000 days) and elevate nutrition on the global agenda (Table 1)].

Table 1: Total and per capita food-fish supplies by region and economic grouping, 2009.

<table>
<thead>
<tr>
<th>Region</th>
<th>Total food-fish supply (\times 10^6) t live mass equivalent</th>
<th>Per capita food-fish supply (kg year(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>92.1</td>
<td>13.9</td>
</tr>
<tr>
<td>Asia</td>
<td>60.7</td>
<td>15.0</td>
</tr>
<tr>
<td>World (excluding China)</td>
<td>66.1</td>
<td>12.5</td>
</tr>
<tr>
<td>Africa</td>
<td>8.6</td>
<td>9.2</td>
</tr>
<tr>
<td>North America</td>
<td>4.9</td>
<td>14.4</td>
</tr>
<tr>
<td>Latin America and the Caribbean*</td>
<td>4.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Europe</td>
<td>12.8</td>
<td>17.4</td>
</tr>
<tr>
<td>Oceania</td>
<td>0.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Least developed countries</td>
<td>8.5</td>
<td>11.9</td>
</tr>
<tr>
<td>Low-income food-deficit countries</td>
<td>27.7</td>
<td>10.5</td>
</tr>
</tbody>
</table>

*Data for Central and South America and Caribbean combined.

Figure 2: World fish production and market.
2. BACKGROUND ON TILAPIA SPECIES

2.1. Nile tilapia (Oreochromis niloticus)

The Nile tilapia Oreochromis niloticus is a deep-bodied fish with cycloid scales. Silver in color with olive/grey/black body bars, the Nile tilapia often flushes red during the breeding season (Picker & Griffiths, 2011). It grows to a maximum length of 62 cm, weighing 3.65 kg (at an estimated 9 years of age), FAO, 2012. The average size (total length) of O. niloticus is 20 cm (Bwanika et al., 2004).

There are three major taxonomic groups. Species of the genus Tilapia are substrate brooders which deposit their eggs in nests excavated in the sediment. Species of the genus Oreochromis are maternal mouth brooders, e.g., the females incubate the eggs in their mouths. Species of the genus Sarotherdon are maternal and paternal mouth brooders (Teichert-Coddington et al., 1997). Global harvest of tilapia in million tonnes as reported by the FAO, 1950–2009 indicated that the major aquaculture species is the Nile tilapia (O. niloticus) (Figure 3). Other important aquaculture species are the blue tilapia (O. aureus), Java tilapia (O. mossambicus), and Zanzibar tilapia (O. hornorum). The red tilapia (O. hybrids) developed from crosses of the main Oreochromis culture species also has become popular in recent years. Other tilapia species are cultured only by small-scale farmers in Africa (Teichert-Coddington et al., 1997).

Figure 3: FAO 2012, Fisheries and Aquaculture Department Statistics.

2.2. Natural distribution and habitat.

O. niloticus is native to Central and North Africa and the Middle East (Boyd, 2004). It is a tropical freshwater and brackish water species. It prefers shallow, still waters on the edge of lakes and wide rivers with sufficient vegetation (Picker & Griffiths, 2011).

Tilapias have been introduced in many countries around the world. It has originated more than 4000 years ago from Egypt. The first culture of tilapia was conducted in Kenya in 1924. Of the 70 species of tilapias, 9 are used in farming and of these, Nile tilapia (Oreochromis niloticus) is the main cultured species. The species is being farmed in about 85 countries worldwide (FAO 2002) Fig. (4).

Figure 4: Native (green) and introduced (red) ranges of O. niloticus globally (Data source: GISP 2012). Please note this map does not indicate country wide presence, but merely that the species is categorized as an alien within that country.
2.3. Feeding habits

Nile tilapia is omnivores mainly herbivores. It feeds on a short food chain in fish pond, Fig. (5). This reduces the cost of tilapia farming, reduces fishing pressure on prey species, avoids concentrating toxins that accumulate at higher levels of the food chain and makes tilapia the preferred “aquatic chickens” of the trade (Barlow, 2000).

Tilapia feed on plankton, green leaves, benthic organisms, aquatic invertebrates, detritus, and decaying organic matter. They also readily adapt to eating pelleted fish feed. Nevertheless, they are often considered to be filter-feeders because they can trap plankton in mucous excreted from their gills and swallow the plankton-rich bolus (Fryer and Iles, 1972). They have a long intestine necessary to digest plant material. Moreover, tilapias are continuous feeders, and when used in their culture, feed should be offered 3 to 4 times per day if practical (Lim, 1989). Tilapia is popular as a culture species because of their ability to efficiently use both natural organisms and artificial feed efficiently under crowded conditions allowing high levels of production. Tilapias are sensitive to low temperature. Optimum growth usually is achieved at 28 to 32°C. Growth declines greatly with decreasing temperature and at 20 to 22°C, growth is about 30% of optimum (Teichert-Coddington et al., 1997).

Feeding usually stops at temperatures less than 16 or 17°C, and temperatures below 10 to 11°C are lethal. The dress-out percentage of tilapia is rather low. The usual fillet yield is about 33 to 35% of live weight.

It typically feeds during daytime hours. It exhibits a behavioral response to light as a main factor contributing to feeding activity. Due to their fast reproductive rate, however, overpopulation often results within groups of Nile tilapia. To obtain the necessary nutrients, night feeding may also occur due to competition for food during the daylight hours. A recent study found evidence that, contrary to popular belief, size dimorphism between the sexes results from differential food conversion efficiency rather than differential amounts of food consumed. Hence, although males and females eat equal amounts of food, males tend to grow larger due to a higher efficiency of converting food to energy. Male monosex groups displayed higher specific growth rates (SGR) and a lower food conversion ratio than female monosex and mixed groups. The SGR of males was higher in the monosex than in the mixed groups, whereas females of mixed and monosex groups displayed no significant difference in SGR. The efficiency of food utilization was also analyzed indicating nutrient retention ratios were higher in male monosex than in female monosex and mixed groups. Males
displayed a distinctly higher metabolic capacity. Differences in sex-related hormones (11 ketotestosterone = 11-KT, 17β-Oestradiol = 17β-E2) and a metabolic hormone (triiodothyronine = T3) were observed between males and females (Toguyeni, A. et al, 1997).

2.4. Global tilapia production:

It was postulated that in 2013 supplies for tilapia will increase from major producers, other than China, such as Egypt, Indonesia, Philippines, Thailand and Brazil. Domestic markets will increasingly be the focus of producing countries with appreciation of currencies against the US dollar and euro. This is a continuation of the trend in 2012 as production in that year is estimated to be higher than the 2011 global production of 3.58 million tones.

The top ten tilapia producers together supplied 88% of global tilapia production in 2011, which totaled 3.585 million tones. Indonesia and Brazil experienced the fastest growth over a period of one year from 2010 by 31% and 63% respectively. Chinese tilapia production in 2012 was lower as a result of severe weather and disease problems Figure (6).

“Tilapia is the motor that’s driving much of the growth in our sample of species,” as Tvetera (2013) thought. Global tilapia production, which totaled less than 500,000 metric tons in the early 1990s, topped 3.5 million MT in 2011. In 2012 it was expected to have increased 2.7 percent, and this year it is forecasted to climb 3.4 percent, said Tveteras. By 2014, “we should approach around 3.9 million MT,” he added (Fig. 7).

China is by far the largest producer of tilapia, with a production estimated at 1.3 million MT in 2011, accounting for about 40 percent of the global production. Other main producing countries of farmed tilapia are Egypt (almost 600,000 MT in 2011), and Indonesia (500,000 MT) Fig. (8).

In an article on “Global fish production and trends in 2012-2013”, presented by Dr Ragnar Tveteras on Day 1 of the Global Aquaculture Alliance’s GOAL 2012 conference in Bangkok, looks at the supply situation of internationally traded fish species, particularly those imported to the US, Europe and Japan in 2012 and forecasts for 2013 Figure (9).
Aguilar-Manjarrez (1998) described the distribution of small-scale and commercial scale culture opportunities for Nile tilapia in Africa (Figure 10).

2.5. **Status of fish production in Egypt**

Capture fisheries in Egypt are in decline due to; overfishing, pollution, illegal, unreported and Unregulated fishing (IUU), relaxation in the implementation of laws and regulations, lack of interest in clearing Straits and waterways, poor sustainable management of fisheries and aquaculture, illegal fishing operations of fry. In addition to the building of Aswan High Dam (that reduced the annual flood cycle of the Nile), the application of partial pond flushing, aeration and sex reversal are the major steps that contributed to the expansion, intensification and growth of total tilapia production in ponds in Egypt.

The General Authority for Fish Resources Development (GAFRD) planned two-sided strategy aims to increase the productivity of freshwater aquaculture operations, while encouraging investment in marine aquaculture.
Aquaculture in Egypt witnessed a significant and rapid expansion over the last few years. While semi-intensive fish culture in earthen ponds is, by far, the most important farming system in Egypt, recent years have witnessed a rapid development of intensive systems in both tanks and cages in addition to farming in the desert.

**Table 2:** Annual fish production from aquaculture from different farming systems, Egypt, (GAFRD, fish statistics year book, 2012)

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<tbody>
<tr>
<td>Governmental farms</td>
<td>9509</td>
<td>10092</td>
<td>10680</td>
<td>6605</td>
<td>8547</td>
<td>8539</td>
<td>7955</td>
<td>7588</td>
<td>7183</td>
<td>7256</td>
</tr>
<tr>
<td>Private farms</td>
<td>720412</td>
<td>721684</td>
<td>716801</td>
<td>591276</td>
<td>586435</td>
<td>557822</td>
<td>498885</td>
<td>492246</td>
<td>394666</td>
<td>387516</td>
</tr>
<tr>
<td>Semi-intensive</td>
<td>1451</td>
<td>3115</td>
<td>1893</td>
<td>1860</td>
<td>1825</td>
<td>1580</td>
<td>2472</td>
<td>2472</td>
<td>2080</td>
<td>1030</td>
</tr>
<tr>
<td>Intensive</td>
<td>2444</td>
<td>700</td>
<td>700</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cages</td>
<td>249385</td>
<td>216122</td>
<td>160288</td>
<td>68049</td>
<td>69108</td>
<td>62276</td>
<td>80141</td>
<td>19839</td>
<td>50403</td>
<td>32059</td>
</tr>
<tr>
<td>Rice fields</td>
<td>34537</td>
<td>35107</td>
<td>29223</td>
<td>37700</td>
<td>27900</td>
<td>5300</td>
<td>5576</td>
<td>17603</td>
<td>17203</td>
<td>17006</td>
</tr>
<tr>
<td>Total Aquaculture</td>
<td>1017738</td>
<td>986820</td>
<td>919585</td>
<td>705490</td>
<td>693815</td>
<td>635517</td>
<td>595029</td>
<td>539747</td>
<td>471535</td>
<td>444867</td>
</tr>
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Total fish production in Egypt in 2012, estimated as 1.371975 tonnes valued about 17.651950 billion EGP about (1.3 billion dollars) as compared with 2011 which was 16.819000 billion EGP. The annual consumption per individual reached 16.5 kg.

**Table 3:** Contribution of fish sector in national agriculture income, 2011.

Fish farming in Egypt currently represents the largest part of production, where it reached up to 74% of the total production and the private sector share of this production is more than 99% Fig (12).
There are few species used in aquaculture. Some of which are native while few are introduced. However, three groups compromise more than 95% of aquaculture production and their percentage contributions total production are tilapias (75.54%), mullet (12.74%) and carps (6.59%). There are promising practices for African catfish farming. While tilapia is steadily increasing, carps are declining due to marketing problems (GAFRD, 2012).

Egypt boasts of the largest aquaculture industry in Africa, accounting for four out of every five fish farmed on the continent. At global level, Egypt is the second country only after China in the production of tilapia. The majority of farmed fish are either freshwater species or those that can grow in brackish water using semi-intensive method.

Mariculture is still at the stage of infancy facing some technical and economic problems; this culture system contributes only to about five percent to the national total fish production, but could be the future of marine aquaculture in Egypt. Egypt certainly needs some foreign expertise in the field of marine aquaculture. Egypt has a lot to offer in freshwater aquaculture practices.

Fish farmers usually rent the land directly from the Government and annual rental costs are rather low and range between 200 and 500 EGP per feddan (USD 35 – 85). Conversely the cost for purchasing the land is substantial, ranging between 50,000 and 150,000 EGP per feddan (USD 9,000 – 26,000). Usually only farmers willing to build intensive systems buy the land, since they are afraid that the rental contract might not be renewed and that the large initial investment might be lost, Fig. (13). The costs of establishing an intensive production system are considerable: 250,000 – 300,000 EGP (USD 43,000 – 52,000) per feddan for the construction of the tanks and 80,000 – 120,000 EGP (USD 14,000 – 21,000) per feddan for the equipment.
In the arid areas an additional cost relates to the drilling of deep well that can cost as much as 150,000 EGP (USD 26,000). In comparison with the intensive system, production in ponds requires a much lower initial capital: pond construction costs between 2,000 and 3,000 EGP (USD 350 – 500) per feddan while the cost for equipment range between 1,000 and 3,000 EGP (USD 170 – 500) per feddan (Diego Naziri, 2011).

**Types of control measures** required for successful aquaculture are:

i. Control of reproduction

ii. Control of growth and

iii. Control of diseases and natural enemies.

Figure 13: The main aquaculture production sites Source: FAO (2010).
3. **WHY NILE TILAPIA**

Tilapia is of great importance in many areas of the world, especially the tropics as this fish is characterized by a set of qualities that makes it suitable for breeding in farms. Some of these qualities include:

1. High growth rate (can grow to almost 800 g in 1 year).
2. Prolific breeder; females produce about 500 eggs every second week, in some species.
3. They resist disease very well. However, there are usually fewer problems with disease and water quality in tilapia culture than in the culture of most species.
4. They can tolerate low dissolved oxygen concentration, high ammonia concentration, and low water quality in general.
5. They have the ability to reproduce in captivity and short generation time.
6. They feed on low trophic levels (short food chain) and use the aquatic detritus (bioflocs). They accept artificial feeds immediately after yolk-sac absorption.
7. They are 98% vegetarian and can obtain most of its protein requirement from the plant origin; They are environmentally friendly fish.
8. That can adapt and grow in a wide range of salinity.
9. They have the advantage of food for direct consumption, and do not contain the bones within the tissue sarcomas.
10. Their musculature tissue has a scanty amount of fat so, they accumulate a very tiny amount of the organic pollutants.
11. They reach market size at a short period and consequently minimize the time of exposure for the pollutants.

Tilapia in Egypt occupies the first place from the total production reaching about 75.54 % in both wild and aquaculture (Fig.14, 15)

![Figure 14: Tilapia production and other fishes](image1)

![Figure 15: Nile tilapia by source](image2)

3.1. **Classification and nomenclatures:**

The name ‘tilapia’ was derived from the African Bushman word meaning ‘fish’ (Trewavas, 1982). The classification of Tilapia is as follows:

Kingdom: Animalia; Phylum: Chordata; Class: Actinopterygii; Order: Perciformes; Family: Cichlidae; Sub-family: Pseudocrenilabrinae; Tribe: Tilapiini; Genus: Tilapia.

Based on the method of reproduction tilapia is classified into three genera; Mouth brooder, e.g. Oreochromis, where the female incubates the eggs in her mouth; Sarotherodon where the female or the male incubates the
eggs in her or his mouth and Substrate brooder (Tilapia) where the female lays the eggs on the substrate. The common name tilapia is based on the name of the cichlid genus Tilapia, which is itself a latinisation of tilapia, the Tswana word for fish. The genus name and term was first introduced by Scottish zoologist Andrew Smith in 1840. Tilapia represents more than hundred species, the best known of which is the Nile tilapia (Oreochromis niloticus).

3.2. Water quality and environmental conditions and reproduction:

Water temperature: 22–30°C, pH: 6.5 - 9.0 (related to water temp.), dissolved oxygen level (O2) required < 5 mg/L, free carbon dioxide - 2 - 12 mg/L, total alkalinity: 10 - 100 mg/L, total hardness: 50 - 250 mg/L and salinity: -1 -15 ppm.

Reproduction, age, size at maturity and breeding vary with environmental conditions. The species reach sexual maturity at 5-6 months in hatcheries (even 2-3 months when only 30g for some species), spawn 4-6 times per year, 100-500 eggs per brood. Morphological color changes during breeding; parental care, males construct the nest and females rear the fry until free-swimming.

The demand of tilapia fish is increasing in international market day by day. That encourages the business and research for more production. Tilapia can be produced twice a year. If modern farming methods and technology can be used, then it would generate more income. Tilapia farming has a great prospect to contribute to national economies in Africa.

3.3. Research needs

- Training programs for technical labors in all sectors
- Programs to upgrade skills of technical and extension administrators
- Organization training, seminars and workshops
- Production of all male tilapia
- Feed and feeding improvement
- Water recycling technologies
- Hybrid tilapia and other species, etc.
- Promotion of polyculture system
- Pond fertilization
- Polyunsaturated fatty acids improvement
- Seed production
- Marketing

Training needs in the choice of fish through:

- Genetic improvement programs for producing strains of fish that meet the needs of poor producers and consumers;
- Reduced risks of disease;
- Adoption of better fertilizer and feed management systems;
- Aquaculture certification which has limits as a means of governing sustainable production. Certified seafood is currently limited to the US and EU. Only a 4.6% of the global aquaculture production is currently certified. The 13 main species currently covered by the Aquaculture Stewardship Council (ASC) currently account for 41.6% of the worldwide aquaculture production;
- Ensure the knowledge transfer and networking systems;
- Member States must prepare their multiannual national strategic plans, taking into consideration each country’s specific starting conditions, challenges and potential.
• Assist in coordinating activities, exchanging best practices and in providing further guidance on how to reconcile, in practice economic activities with the international legislations.

3.4. **Farming facilities and management methods**

Egypt is trying hard to work on the sustainable aquaculture development. Sustainable aquaculture technologies focus on increasing aquaculture production and productivity to maximize impacts on poverty and hunger without compromising the environment.

Modern sustainable aquaculture may meet the demand for fish by production of fish with high quantity and quality with low utilization of water and land resources. To develop appropriate technologies, improve management, secure access to essential inputs (quality seed, fertilizers and feed and affordable credit) and improve access to markets.

A traditional form of aquaculture, known as “hosha”, has been commonly practiced for many centuries in the Northern Delta Lakes Region until a few decades ago but it is not an economical practice.

There are many fish farming types and facilities in Egypt that include excavated earthen ponds, pens and enclosures, concrete and raceways ponds, circular tanks and floating fish cages. Also there are different production systems and management methods which are classified according to the intensification (extensive, semi-intensive and intensive or according to the fish cultured species (monoculture and polyculture). The most common prevailing fish farms in Egypt is earthen ponds semi-intensive and in last few years the intensive fish farming has grown increasingly especially in the desert since 2010. Integrated fish farming system has also witnessed a significant development (aquaculture in rice fields, animal rearing on aquaculture and fish - animal- plant integration), Table (4).

**Table 4: Annual trend of aquaculture/MT, 2003 - 2013**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Governmental Farm</td>
<td></td>
<td>9509</td>
<td>10092</td>
<td>10680</td>
<td>6665</td>
<td>8547</td>
<td>8389</td>
<td>7955</td>
<td>7587</td>
<td>7183</td>
<td>7256</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Farm</td>
<td></td>
<td>22041</td>
<td>21684</td>
<td>716801</td>
<td>591276</td>
<td>586435</td>
<td>557822</td>
<td>498885</td>
<td>492246</td>
<td>394660</td>
<td>387156</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cages</td>
<td></td>
<td>249385</td>
<td>216222</td>
<td>160288</td>
<td>60469</td>
<td>69108</td>
<td>62276</td>
<td>80141</td>
<td>19838</td>
<td>17803</td>
<td>50403</td>
<td>32059</td>
<td></td>
</tr>
<tr>
<td>Aquaculture in rice fields</td>
<td></td>
<td>34537</td>
<td>35107</td>
<td>29223</td>
<td>37860</td>
<td>27903</td>
<td>53000</td>
<td>5576</td>
<td>17602</td>
<td>17202</td>
<td>17005</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Semi-Intensive Aquaculture</td>
<td></td>
<td>1451</td>
<td>3115</td>
<td>1893</td>
<td>1846</td>
<td>1825</td>
<td>1580</td>
<td>2472</td>
<td>2472</td>
<td>2090</td>
<td>1030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive Aquaculture *</td>
<td></td>
<td>2444</td>
<td>706</td>
<td>700</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1017738</td>
<td>986820</td>
<td>919585</td>
<td>705490</td>
<td>693815</td>
<td>635517</td>
<td>595029</td>
<td>539746</td>
<td>471534</td>
<td>4441668</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Started to be confined as possible at some regions in 2010

**3.4.1. Earthen ponds**

In Egypt, extensive culture systems in earthen ponds is the major type of culture system where only waste lands are allowed to be used for fish mainly because of their salt and alkaline content and poor drainage. Semi-intensive aquaculture which is mostly practiced (and most farms located) in the northern or eastern part of Nile Delta (photo) (1).
3.4.2. **Concrete ponds:**
The pioneer facility for intensive production comprises of a parallel sets of narrow channels constructed in sequential blocks, photo (2).

3.4.3. **Floating cages:**
Fish cage culture system also widely used especially in the Nile Delta region where semi-intensive and intensive farming is practiced with a total production reaching to 249385 tonnes in 2012 (GAFRD, 2012).

Cage culture of fish uses existing water resources but encloses the fish in a cage or basket. These cages float and are placed in the open part of the pond with at least two feet of water between the bottom of the cage and the pond bottom, photo (3).
Intensive fish cage culture is rapidly developing and now contributes to around 10% of total aquaculture production in Egypt. Nile tilapia is the principal cage culture species. The sizes of the cages vary from small cages of around 32 m³ to larger cages of around 600 m³. Smaller cages (2–4 m³) suspended in drainage canals are also used in rural areas. The yield varies between 5 to 35 Kg/m³ (El-Sayed, 2007).

3.4.4. Extensive
Extensive culture systems in Egypt are characterized by a low level of intervention, i.e. limited feeding and fertilization, low investment capital, and primitive management table (5).

3.4.5. Semi-Intensive:
Semi-intensive fish culture in earthen ponds is, by far, the most important farming system in Egypt. Semi-intensive pond aquaculture is the basic system used in the country and about 86% of aquaculture production is obtained from these systems. Most of the farms are located in the northern and eastern parts of the Nile Delta where they utilize both brackish and freshwater. Fish ponds vary in size from 1 to 25 feddan (0.5-12 Ha). Polyculture is the most common type of production but monoculture of Nile tilapia is also practiced in many areas. The stocking densities, energy input, level of management as well as the size and type of infrastructure vary greatly among different farms (El- Sayed, 2007). Annual production in semi-intensive systems varies from 2 to 10 MT/feddan (5-25 MT/Ha) table (5).

3.4.6. Intensive:
100 intensive tilapia rural farms and 20 commercial aquaculture farms were established in the desert. These projects account for just 3% of the overall aquaculture production of Egypt, FAO (2011).

Intensive pond culture is another rapidly developing sector in the last ten years. Concrete tanks are used within integrated aquaculture and desert agriculture systems. This type of production is currently creating a growing awareness and gaining increasing acceptance as a result of the high rate of return on the utilization of water. The total number of registered farms is currently 530 with an annual production of 2444 MT, 0.9% of total fish production (GAFRD, 2012). Nile tilapia (mainly monosex) is the major cultured species. Annual production ranges from 40 to 60 MT/feddan table (5) and Table (6).

Table 5: Production systems e.g. in Behera and Dakahlia Governorate.
Table 6: Production of fish by fish group according to the farming system.

<table>
<thead>
<tr>
<th>Com. Name</th>
<th>Total Production</th>
<th>Aquaculture in Rice Fields</th>
<th>Intensive Aquaculture</th>
<th>Semi-Intensive Aquaculture</th>
<th>Cages</th>
<th>Earthen Ponds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilapia nej</td>
<td>768752</td>
<td>17722</td>
<td>2436</td>
<td>1215</td>
<td>212383</td>
<td>528030</td>
</tr>
<tr>
<td>Mullets nej</td>
<td>129651</td>
<td>-</td>
<td>8</td>
<td>-</td>
<td>35343</td>
<td>93405</td>
</tr>
<tr>
<td>Carp *</td>
<td>67065</td>
<td>6477</td>
<td>-</td>
<td>-</td>
<td>1359</td>
<td>58263</td>
</tr>
<tr>
<td>Gilthead seabream</td>
<td>14806</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>-</td>
<td>14747</td>
</tr>
<tr>
<td>European seabass</td>
<td>13798</td>
<td>-</td>
<td>50</td>
<td>300</td>
<td>13239</td>
<td>209</td>
</tr>
<tr>
<td>Catfishes</td>
<td>13622</td>
<td>10338</td>
<td>-</td>
<td>135</td>
<td>-</td>
<td>2695</td>
</tr>
<tr>
<td>Meagre</td>
<td>8319</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8319</td>
</tr>
<tr>
<td>Shrimps nej</td>
<td>1109</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1109</td>
</tr>
<tr>
<td>Caranx spp</td>
<td>613</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>605</td>
</tr>
<tr>
<td>Eels nej</td>
<td>11</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1017738</strong></td>
<td><strong>34537</strong></td>
<td><strong>2444</strong></td>
<td><strong>1451</strong></td>
<td><strong>249385</strong></td>
<td><strong>720412</strong></td>
</tr>
</tbody>
</table>

3.4.7. Economics of intensive and semi-intensive farming

Investment and running costs are substantial. Fish farmers usually rent the land directly from the Government and annual rental costs are rather low and range between 200 and 500 EGP per feddan (USD 35 – 85). Conversely, the cost for purchasing the land is substantial, ranging between 50,000 and 150,000 EGP per feddan (USD 9,000 – 26,000). Usually only farmers willing to build intensive systems buy the land, since they are afraid that the rental contract might not be renewed and that the large initial investment might be lost. The costs for establishing an intensive production system are considerable: 250,000 – 300,000 EGP (USD 43,000 – 52,000) per feddan and for the construction of the tanks 80,000 – 120,000 EGP (USD 14,000 – 21,000) per feddan for the equipment. In desert areas an additional cost relates to the drilling of deep wells that can cost as much as 150,000 EGP (USD 26,000). In comparison with the intensive system, production in ponds requires a much lower initial capital: pond construction costs between 2,000 and 3,000 EGP (USD 350 – 500) per feddan while the cost for equipment range between 1,000 and 3,000 EGP (USD 170 – 500) per feddan. Financial Services for Small and Medium-scale Enterprise (SME) Egypt Case study, Diego Naziri. 25 January 2011 table (6).

According to the information gathered both by the officers of GAFRD and fish farmers, tilapia production
seems to be a highly profitable business. Table (7) presents the basic economics of fish farming for two different production systems: one semi-intensive production in ponds and one intensive production in tanks. (Diego Naziri, 2011)

Table 7: Economics of tilapia fish farming

<table>
<thead>
<tr>
<th>Item</th>
<th>Semi-intensive (ponds)</th>
<th>% run. cost</th>
<th>% tot. cost</th>
<th>Intensive (tanks)</th>
<th>% run. cost</th>
<th>% tot. cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. of units</td>
<td>10</td>
<td></td>
<td></td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area/unit (feddan)</td>
<td>2</td>
<td>0.05 (= 210 m2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual aquaculture area (feddan)</td>
<td>20</td>
<td></td>
<td></td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total rented area (feddan)</td>
<td>25</td>
<td></td>
<td></td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost for land rental (EGP/feddan)</td>
<td>350</td>
<td></td>
<td></td>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction cost (EGP/feddan)</td>
<td>2,600</td>
<td></td>
<td></td>
<td>280,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment cost (EGP/feddan)</td>
<td>2,000</td>
<td></td>
<td></td>
<td>100,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed (n./feddan)</td>
<td>30,000</td>
<td></td>
<td></td>
<td>240,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival rate</td>
<td>80%</td>
<td></td>
<td></td>
<td>80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price of seed (EGP/1,000 seed)</td>
<td>50</td>
<td></td>
<td></td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish size at harvest (pieces per Kg)</td>
<td>4</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCR (Feed Conversion Ratio)</td>
<td>1.5</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual production (t)</td>
<td>120</td>
<td></td>
<td></td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual feed consumption (t)</td>
<td>180</td>
<td></td>
<td></td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price of feed (EGP/Kg)</td>
<td>3.3</td>
<td></td>
<td></td>
<td>3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salary permanent worker (EGP/year)</td>
<td>0,000</td>
<td></td>
<td></td>
<td>0,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salary seasonal worker (EGP/day)</td>
<td>40</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tilapia price (EGP/Kg)</td>
<td>8.75</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial investment (EGP)</strong></td>
<td><strong>112,500</strong></td>
<td></td>
<td></td>
<td><strong>950,000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>62,500</td>
<td></td>
<td></td>
<td>700,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>50,000</td>
<td></td>
<td></td>
<td>250,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fixed costs (EGP/year)</strong></td>
<td><strong>18,133</strong></td>
<td>2.5</td>
<td></td>
<td><strong>128,555</strong></td>
<td>15.6</td>
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<tr>
<td>Construction depreciation (8%, 20 years)</td>
<td>6,111</td>
<td>0.8</td>
<td></td>
<td>68,445</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>Equipment depreciation (8%, 5 years)</td>
<td>12,022</td>
<td>1.7</td>
<td></td>
<td>60,110</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td><strong>Running cost (EGP/year)</strong></td>
<td><strong>707,460</strong></td>
<td>100.0</td>
<td>97.5</td>
<td><strong>696,670</strong></td>
<td>100.0</td>
<td>84.4</td>
</tr>
<tr>
<td>Land rental</td>
<td>8,750</td>
<td>1.2</td>
<td>1.2</td>
<td>875</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Seed</td>
<td>30,000</td>
<td>4.2</td>
<td>4.1</td>
<td>30,000</td>
<td>4.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Feed</td>
<td>594,000</td>
<td>84.0</td>
<td>81.9</td>
<td>594,000</td>
<td>85.3</td>
<td>72.0</td>
</tr>
<tr>
<td>Organic fertilizers</td>
<td>3,000</td>
<td>0.4</td>
<td>0.4</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Chemical fertilizers</td>
<td>1,500</td>
<td>0.2</td>
<td>0.2</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Permanent labour</td>
<td>27,000</td>
<td>3.8</td>
<td>3.7</td>
<td>27,000</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Seasonal labour</td>
<td>4,000</td>
<td>0.6</td>
<td>0.6</td>
<td>2,000</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Fuel/electricity</td>
<td>9,000</td>
<td>1.3</td>
<td>1.2</td>
<td>12,000</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Other (maintenance, license)</td>
<td>3,000</td>
<td>0.4</td>
<td>0.4</td>
<td>4,000</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Interest on the running cost (8%)</td>
<td>27,210</td>
<td>3.8</td>
<td>3.8</td>
<td>26,795</td>
<td>3.8</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>TOTAL COST (EGP/year)</strong></td>
<td><strong>725,593</strong></td>
<td>100.0</td>
<td></td>
<td><strong>825,225</strong></td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL INCOME (EGP/year)</strong></td>
<td><strong>1,050,000</strong></td>
<td></td>
<td></td>
<td><strong>1,200,000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROFIT (EGP/year)</strong></td>
<td><strong>324,407</strong></td>
<td></td>
<td></td>
<td><strong>374,775</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RUNNING COST PER KG (EGP/Kg)</strong></td>
<td><strong>5.9</strong></td>
<td></td>
<td></td>
<td><strong>5.8</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL COST PER KG (EGP/Kg)</strong></td>
<td><strong>6.0</strong></td>
<td></td>
<td></td>
<td><strong>6.9</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROFIT PER KG (EGP/Kg)</strong></td>
<td><strong>2.7</strong></td>
<td></td>
<td></td>
<td><strong>3.1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROFIT PER LAND UNIT (EGP/feddan)</strong></td>
<td><strong>12,976</strong></td>
<td></td>
<td></td>
<td><strong>149,910</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The annual production of the two presented systems is the same, namely 120 tonnes per year. As already mentioned, the yield in semi-intensive systems is significantly lower than in intensive systems: we have assumed 6 tonnes/feddan and 40 MT/feddan, respectively. The former system requires a total area of 24 feddan (about 10 Ha) while the size of the intensive farm is only 2.5 feddan (about 1 Ha). It is worthwhile mentioning that in the semi-intensive systems about 80% of the land is actually occupied by the ponds, the rest being taken by canals and roads. In the case of production in tanks, only half of the area is occupied by the tanks themselves, while the remaining area is taken by roads and space among the tanks (usually they have a round shape).

3.4.8. **Closed or recalculate aquaculture system (RAS)**

It is a highly modernized method for super intensification. Leading to reducing water requirements, year round production, ability to use existing buildings, high yields per cubic meter of water, improved feed conversion, reduced reproduction and more control. On the other hand it has the disadvantages of i. high initial investment, complexity, ii. chronic sub-lethal effects of ammonia and iii. carbon dioxide and inefficiencies in filtration.

Water re-use systems are employed in countries where water is scarce or in temperate climates where heated water must be used to permit year-around production (e.g. Egypt). Of course, in temperate countries, brood stock can be maintained during cold months in heated systems and production done during warm months in ponds, cages, fish production re-use systems is done intensively in earthen ponds or concrete tanks at high water exchange rates and the water is recirculated through a large reservoir which serves as a water treatment system (photo 4). The most advanced recirculating systems employ culture tanks and water treatment facilities often located indoors in greenhouses or other heated facilities. The most common methods of water treatment in re-circulation systems are mechanical aeration to add dissolved oxygen, mechanical filters to remove large particles, biological filters to enhance nitrification (oxidize ammonia to nitrate), and sedimentation to remove solids (Soderberg, 1994). Treatment with liming materials also is necessary to neutralize acidity from nitrification.

Radwan (2008) explained that his first impression of aquaculture in recirculation systems had not been positive due to the high investment costs. But as a practical person he was interested to apply it on his farm. This was made possible and more attractive after the information obtained from a training course in Wageningen (2006) and from a study visit to Dutch fish farms that operate recirculation systems (2008). The material support (two pumps, generator) provided by the Netherlands Embassy made the installation possible for a recirculation system. Making use of 24 existing concrete fish tanks (10.8 m volume) Radwan installed a sedimentation pond and built a trickling filter, producing the plastic filter material himself from plastic fencing material that is available locally photo (5). The recirculation system became operational in April, 2009. Starting with stocking capacity of 1000 pieces of 250 g. fish per tank, 450 kg/tank could harvested after 100 days, having reached a maximum fish density of 41.6 kg/m tank volume. Since this first trial 2 more successful production cycles have taken place. The production cycle of 2010 resulted in 18,935 kg of fish with a total cost of LE 141,368. The total sales value was LE 174,485. The owner is at present expanding his RAS facility with a mobile bio- filter.
An Industry Assessment of Tilapia Farming in Egypt

The water pumping facility of the project is by two 15-kw electric pumps (one pump in operation while the second one is on standby).
4. INTEGRATED FISH FARMING

4.1. Rice field aquaculture

GAFRD is propagating this type of aquaculture in Egypt by supplying the farmers with the fingerlings for free through the national project, by the agricultural card holding for farmers.

There are two methods for rearing of fish in rice field,

1. Simultaneous method.
2. Alternate method.

The most common method in Egypt is the simultaneous in which both rice and fish are grown together and it is the real rice fish cultivation photo (5). The fish production from rice field in 2012 reached to 34537 tonnes (GAFRD, 2012).

Advantages of simultaneous method:

- It maximizes utilization of available land.
- Increase the rice crop by about 5-15% through controlling weed and algae, which compete with rice and help in fertilization of rice field by fish excreta.
- Production of cheaply animal protein of low costs.
- It creates hygienic medium through control of mollusca and harmful insects.

![Photo 8: simultaneous rice field integrated fish production](image)

4.2. Integrated fish culture with farm animals

Many forms of integrated fish farming with farm animals and also in combination with both plant and farm animals had been practiced in Egypt since the last few years and will be discussed in the context of fish farming in desert (Arid aquaculture).

Abdel – Hakim et al. (2000) experimentally developed practical aquaculture systems for polyculture using duck and buffalo manures during one growing season (100 days) in earthen ponds. The treatments applied are buffalo manure only (BM), buffalo manure with supplementary feed (BM+F), duck manure only (DM) and duck manure with supplementary feed (DM+F). Each treatment was performed in triplicate each in an earthen pond of an area of 2000 m². Each pond was stocked with 3000 Nile tilapia (Oreochromis niloticus), 940 blue tilapia (O. aureus), and 60 common carp (Cyprinus carpio). The obtained results can be summarized as follow:

- At the experiment start, body weight and body length of Nile tilapia were relatively similar and after 30 days of the experiment, body weights among treatment groups were significantly different and these differences continued till harvesting where the DM+F treatment produced the heaviest and longest fish
bodies compared to the other treatments.

- Body weight and body length of blue tilapia and common carp showed the same trend of Nile tilapia. Specific growth rate (SGR) of Nile tilapia, blue tilapia and common carp were higher in treatments received BM+F and DM compared to those received BM or DM only and the differences were significant.
- The higher total fish production was obtained by DM+F group followed in a significant decreasing order by the other groups, BM+F; DM and BM, respectively .
- The net return (total returns - total costs) were 5036, 4739, 6657 and 5741 LE for the different treatments, BM; BM+F; DM and DM+F, respectively. Therefore, DM group recorded the best returns compared to the other treatment.

4.3. **Aquaponics**

A combination of **aquaculture** (raising fish in a controlled environment) and **hydroponics** (growing plants without soil, providing the nutrients to the plants mixed into the water fed to the plants). Aquaponics is growing woods in the desert and yielding harvests in the city. In practice, Nile tilapia is the most popular fish chosen for this system. In Egypt few trials have been experienced. One of these trials was transferred from Virgin Islands University and brought the technique to Egypt, where the country’s first commercial aquaponics farm has started. Water circulates through tanks full of Nile tilapia, then the fish-waste laden water is treated and filtered and then flows over through trays where vegetables grow, and eventually out to irrigate the olive trees that line the farm.
5. **AQUACULTURE IN DESERT**

Today, Egyptian desert aquaculture comprises more than 100 intensive tilapia rural farms and 20 commercial aquaculture farms scattered throughout seven different provinces. The approximate combined surface area of the desert commercial farms is ~893 hectares, with an approximate annual production of 13 000 MT. These 20 commercial farms are capable of producing up to 6 000 MT/year; the remaining 7 000 MT/year are produced in ~100 rural farms. Various finfish species are reared, particularly Nile tilapia (*Oreochromis niloticus*), red tilapia (*Oreochromis mossambicus* × *Oreochromis niloticus*), North African catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idellus*), flathead grey mullet (*Mugil cephalus*), European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and a number of exotic species, mainly koi (*Cyprinus spp.*), fantail (koi variety) and molly (*Poecilia spp.*). The water source comes from underground water reserves and/or agricultural drainage. The latter varies in salinity, ranging from 0.5 to 26 g/liter, and in temperature from 22 to 26 °C. Most of the commercial farms have adopted flow-through systems (FTS) which irrigate agricultural land, giving them the advantages of producing three different crops (fish/plant/sheep). While most of the farms are strictly dependent on FTS, two of them have upgraded their systems to include recirculation aquaculture system (RAS). Among other edible and ornamental fish species, tilapia (*Oreochromis niloticus* and *O. aureus*, or sex-reversed red tilapias) are one of the most promising species. Production of tilapia (in densities of 20–30 kg/m³ to market size of 250–400 g in 6–8 months) is possible due to the suitable warm climate and abundant warm underground water present throughout the year. Although the brackish water used for aquaculture purposes varies in salt concentrations (>25 g/litre), it is utilized for integrated agriculture, e.g. the irrigation of Salicornia crops combined with intensive European seabass and gilthead seabream aquaculture, with a yearly production of 100 tons per year for both species. Most commercial farms are purchasing their fish fry from the local market, and only five have their own hatchery. Issues that affect the development of these commercial aquatic desert farms are associated with the quantity/quality of water; excess of effluent water; fingerling supply; feed quality; feed prices; production overheads cost; lack of technical experience; marine fish diseases; and poor availability of credit (Sadek, 2011).

Tilapias possess an impressive range of characteristics that make them suitable for widespread culture in the desert and arid zones (Fig.16). They also display varying degrees of salt tolerance, a trait resulting in the expansion of their culture into brackish water and saline water. Several tilapia farms have already been integrated into Egyptian desert activities; more than 100 are intensive tilapia rural farms and 20 are pioneer commercial fish farms (photo 9).

![Figure 16: Commercial intensive tilapia farms integrated with agriculture activities in Egyptian desert.](image)
El-Guindy (2006) also noted that brackish water and brine could play a significant role in the sustainable development of desert aquaculture (both environmentally and socially) by implementing:

i. Economically and technically feasible options, obtained through desalination of the underground brackish water; and

ii. Cost-effective technological solutions related to underground brackish water extraction and exploitation for: human food (crops and fish); fodder (crops and aquatic products); fuel (wood and biofuel); existing plant species (halophytes); and new and more salt tolerant agricultural products and other commodities (oils, lubricants, pharmaceuticals, fibers, etc.).
6. **TILAPIA PRODUCTION**

Production could be separated into two phases; production of fingerlings in fish hatcheries and grow-out of fingerlings to marketable size in different rearing facilities.

6.1. **Hatcheries**

Brood fish are spawned in Tilapia hatcheries, eggs are hatched, and fry reared to fingerling size for stocking in culture units. In the present, there are large numbers of freshwater fish hatcheries. Out of which, several hatcheries belong to the government while the majority belong to the private sector. The mode of operation varies among the affiliations of existing hatcheries. Tilapia is the only target species in private sector hatcheries.

Frequency of spawning varies with environmental conditions and can occur at 4- to 6-weeks intervals under ideal conditions in natural environments. In hatcheries, the inter-spawning interval can be shortened and spawning frequency increased by removing eggs from mouth-brooding females (photos 10-18).

Photos 10-18: Nile tilapia indoor and outdoor hatchery facilities.
The expansion in intensive tilapia aquaculture resulted in a boom in the development of privately-owned hatcheries and feed mill construction. This expansion in Nile tilapia was also associated with the production of all male tilapia.

Problems of fish hatcheries:
- Obtaining pure selected strains of broodstock
- To provide high quality food of high nutritional value, maintain proper water quality
- Control of diseases and natural enemies
- Determination of the best time for periodical harvesting to obtain fingerlings closely uniform in size.
- Introduction of predatory or exotic species (photo 19, 20, 21). Red swamp crayfish invasive crustacean invade tilapia nursing ponds considered as a pest as it predates fry (Abbassa fish hatchery)

Photos 19, 20, 21: Exotic crayfish species in fish hatchery.

6.2. Grow-out

Rearing of tilapia is practiced in ponds, cages and net pens, raceways, and water re-circulating systems. Ponds are fertilized with manure and commercial fertilizer to allow production up to 2,000 to 3,000 kg/ha per crop. Much higher production, up to 20,000 kg/ha, is achieved through application of commercial fertilizer and feed as well as the use of mechanical aeration. Water exchange is often applied specially in intensively managed ponds and raceways to improve water quality. Feed usually is offered to fish in all types of production units. Inputs of fertilizer and feed to culture systems result in pollution load in effluents. Cage culture also is common having a design that ranges from simple ones of 1 or 2 m³ volume made on site from netting materials to large manufactured cages. Cages may be located in ponds, reservoirs, lakes, streams, irrigation systems, or estuaries. Regulations have been imposed on the location and number of cages in public waters, but these regulations may not be obeyed. Net pens are used to a lesser extent than cages. Raceways, also referred to as flow-through production systems, are grow-out units through which water flows continuously. Raceways are often elongated concrete troughs 2 to 4m wide and 10 to 50m long.

6.2.1. Pond preparation

One of many methods used:
- The organic fertilizer e.g.; chicken manure is added at a dose of 350 kilometers scattering on the ground, then chemical fertilizer has been added at 10 kg / feddan e.g. ammonium sulfate scattered on the surface of the water level in the pond which reached to a quarter meter of the pond depth which should be left at this level for three days.
- On the fourth day an amount of 10 kg triple superphosphate 45% phosphorus per feddan to be sprayed after dissolved in a suitable amount of water because the lack of solubility leads to lack of benefit from them.
- On the seventh day the water level should be raised to the size of the operation at least one meter within four days.
- Irrigation is stopped and the pond should be left for a week and the transparency of the water is measured
using a Secchi disc and the change the water color to be followed-up till the reading reach 20-25 cm and a turning color to yellowish-green water the pond will be ready to receive the seed.

- In the case of non-attainment levels of transparency to the required level additional amount of chicken manure should be added at a rate of 20 kilo / feddan.
- Secchi disc (transparency disc): Round disc diameters of 20 cm, painted with mutual black and white centralized fixed in the center of a graduated stick.

6.2.2. Pond fertilization

Nile tilapias do well in much enriched waters (enriched by organic and inorganic fertilizers).

The main kinds of fertilizers used in Egypt: 1. Inorganic (chemical); Phosphate, Potassium and Nitrogenous. 2. Organic (manure); chicken manure and cattle manure.

General principles for using chemical fertilizers:

1. Chemical fertilizers are usually required when water temperature is over 18-20°C and in semi-intensive culture system.
2. Standard dose for phosphorus 60 kg/h and for ammonium 60 kg/h every 2 weeks or half of dose every 1 week.
3. Requirement for chemical fertilizers in intensive culture is not clear.

Fertilization rate is affected by:

- Nutrient requirement,
- Availability of nutrient and
- Chemical reactions in pond water.

Fertilization rate should be once every two weeks or once a week using half of the required amount. If the water does not turn green from plankton bloom development after 6 to 8 weeks of fertilization, liming may be necessary. Agricultural limestone will increase water hardness and alkalinity and decrease acidity, thereby increasing the effectiveness of fertilizers. A pond soil sample is needed to determine the lime requirement.

One of the wrong practices is using chicken manure in fish feeding. Rappaport and Sarig (1978) reported that the addition of chicken manure to fish ponds results in reduction of the food conversion rate and Djajadiredja et al. (1980) reported that poultry manure is known to be the most powerful fertilizer for fish ponds. In Egypt, breeder and layer litter are preferred for fish farms because they are considered nutrient-rich due to the quantity of spilled feed they contain.

Application methods:

To ensure the uptake of mineral nutrient by phytoplankton in all part of a pond and to prevent nutrient loss by precipitation or release to the atmosphere due to excessive concentration in some parts of the pond fertilizer must be distributed in the water as evenly as possible. Spreading is done by:

1. Casting the fertilizer over the surface of water from a boat.
2. Spreading by water current produced by even slight wind are good distributing agent.
3. Fertilizers cast in the windward side of pond 2-3 m from the embankment preferably when the prevailing winds are blowing. Winds cause the upper layer of water to move in the direction of wind creating an undercurrent on the opposite direction near the pond bottom distributing the fertilizer and increase nutrient fixation by absorption into soil colloid.
N.B: Liquid ammonia is the cheaper and good fertilizer but care should be taken upon using as it toxic if inhaled or touched. So it spreads by using empty oil drum with plastic tube of 1 cm in diameter (sufficient to drain drum within 2-4 h.). The drum should be placed in the wind ward embankment of the pond where the fertilizer runs through a valve into the water.

Organic fertilizers (Manure):

Importance of using manure:
- Stimulate the growth of bacteria and protozoa, which developed on organic particles which take a part on food chain.
- Have a favorable action on the structure of soil.
- Organic matter is necessary to the action of phosphorus and potassium fertilizers.

Risk from using manure is the depletion of oxygen dissolve and favors certain disease to fish.

Types of manure:
- Liquid cattle manure, chicken manure, and duck manure (Fish duck culture)
- Organic advantages: enhances heterotrophic and autotrophic production (direct and indirect), decomposition liberates CO2 for plants, aid in clearing turbid water, provide long-term enhancement
- Inorganic advantages: enhances autotrophic production (direct), have a more consistent composition, more widely available, more predictable response, smaller application, less labor intensive and easier to store

6.2.3. Stocking rate

The rate of stocking ideally depends on their carrying capacity.

The carrying capacity can be determined according to the inputs. Rearing Nile tilapia in earthen pond with semi-intensive method as an example, if the target (output) is 2,000 kg so, the fish may be stocked at the rate of 9,200/feddan. The basis for this is: target size of tilapia = 250 g; initial size = 2 - 10 g; mortality = 15%; harvest = 6 months after stocking.

\[
\text{Stocking rate} = \frac{\text{Target yield (kg)}}{\text{Target size (kg)}} + \% \text{mortality}
\]

Fish should be “tempered” (slowly acclimated to any significant changes in water temperature or chemistry), when preparing to stock them into a new environment. Proper tempering requires, if no thermometer is available, temperature differences between the two environments should be adjusted gradually until no difference can be felt using your hand. If fish are received packed in plastic bags with oxygen, float the bags in the receiving water without opening them until the fish are temperature acclimated. Opening the bags allows the oxygen to escape, and the fish must be quickly released. If fish are being offloaded from a hauling tank, gradually mix the new water into the tank until temperatures are equalized.
7. TILAPIA FEED AND FEEDING

One of the most important aquaculture industry challenges is feed.

The fish meal trap is the hypothesis that aquaculture is environmentally degrading because increased demand for feed leads to increased fishing effort for the wild species used to produce the feed and thereby threatens the viability of wild fish stocks, and that the growth in aquaculture production will be limited by the availability of wild fish to be used as feed in aquaculture production (Naylor et al., 2000). Using fish as a fish meal to increase aquaculture production at the expense of the wild resources may negate the idea of aquaculture. Feeding of tilapia in earthen ponds is based on two feeding systems; natural feeding and artificial feeding. Natural food is an important source of vitamins and minerals. Also it works to increase the digestive capacity of fish. The development of these objects depends on the type of soil and nutrients in them and can compensate for the lack of these elements by adding organic fertilizers such as chicken manure and chemical compounds, especially phosphorus and nitrogen. The artificial feeding is considered supplementary feeding to help the natural growth of fish quickly during a culture period which varies depending on the type of fish farmed. It is considered as a food supplement to augment the natural food (table 8, 9, photo 22).

Table 8

<table>
<thead>
<tr>
<th>Size of fish (grams)</th>
<th>Standard Feed Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–3</td>
<td># 00, or # 0</td>
</tr>
<tr>
<td>3–10</td>
<td># 1</td>
</tr>
<tr>
<td>10–25</td>
<td># 2</td>
</tr>
<tr>
<td>25–40</td>
<td># 3</td>
</tr>
<tr>
<td>40–100</td>
<td>3/32&quot;</td>
</tr>
<tr>
<td>larger than 100</td>
<td>9/6&quot;</td>
</tr>
</tbody>
</table>

Table 9

<table>
<thead>
<tr>
<th>Size of fish (grams)</th>
<th>Amount of daily feed (% of fish weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1</td>
<td>30–10</td>
</tr>
<tr>
<td>1–5</td>
<td>10–5</td>
</tr>
<tr>
<td>5–20</td>
<td>6–4</td>
</tr>
<tr>
<td>20–100</td>
<td>4–3</td>
</tr>
<tr>
<td>larger than 100</td>
<td>3–1.5</td>
</tr>
</tbody>
</table>

Macfadyen et al. (2011) reports that there are 25 fish feed mills in Egypt, producing more than 300,000 Mt of fish feed each year. Five mills produce extruded fish feed and their production represents around 20 -25% of total fish feed production. Feed mills also provided a wide range of different feed formulations to match the feed requirements of different stages of the life cycle (e.g. different protein content). In addition to the registered mills, there are around 50 small scale pelletizing units, each with an estimated annual production of each of 3,000 – 4,000 tonnes of fish feed with total annual production of 120,000 – 240,000 tonnes. These pelletizing units use simple technologies and, in most cases, are not equipped with air driers.
Fish feed industry is estimated to have a total potential feed market of about 1.5 million tonnes in Egypt; comprising of 29% extruded, 60% pelleted and 31% feeding by products (such as wheat bran). The market for extruded feed is growing and in 2013 several extruder projects are in-progress. More than 60% of the raw materials of fish feed have to be imported in Egypt. Increasing world market prices of raw materials resulted in an increase of feed prices with 200 – 250% over the last 6 – 7 years (Macfedyen et al. 2012)

**Improvement of tilapia feeding**

Researchers in Abbassa carried out a successful field trial on total replacement of fishmeal with locally produced fish meal and soybean meal in diets for Nile tilapia (*Oreochromis niloticus* L.) in pre-fertilized ponds. They obtained results which demonstrated clearly a significant increase in tilapia production from the ponds that were fed with soybean based diets in comparison with those fed with the commercial feed containing fishmeal as the sole animal protein source. Feed conversion ratios from the trial were very encouraging and demonstrated very strongly the significant improvement of the FCR values for the soybean based diets over that for the commercial fishmeal based diet (Fig 17).

**Figure 17:** Shows growth rate, economical parameters, average FCR and total tilapia production.
8. HARVESTING

Fish harvesting in earthen ponds especially in large ponds is a significant task. In Egypt one of the most commonly used methods for harvesting pond grown tilapia involves both seining and draining of the pond. It is hard to catch all the tilapias using only seining since these fishes are skilled escape artists.

- Pond drainage often takes place while fish harvest and any failure in pumping system could lead to harvesting problems and subsequent economic loss (photos 23, 24, 25).
- Catch ponds are recommended to carry out efficient fish harvesting. Catch pond should have a rocky bottom and sides. The bottom of catch pond is 50 – 80 cm below fish pond bottom (photo 26). In order for this method to be effective in attracting pond fishes to enter the catch pond, water is introduced to fish pond through catch pond at a rate of 20-40 m3/hour. This particular catch pond serves 2-3 production ponds; 6 ha each (photo 26).
9. SUCCESS STORIES

How to get the highest economic returns of available groundwater is the most important challenge facing agriculture and reclamation projects (Table 10, Fig 18)

Table 10: Economics of integrated and non-integrated fish farming systems.

<table>
<thead>
<tr>
<th>Comparison between the non-integrated agriculture system and El-Keram agriculture integration project system (fish/clover/sheep/organic fertilizer/biogas) in the Egyptian desert</th>
<th>Item</th>
<th>Non-integrated agriculture production systems</th>
<th>El-Keram integration systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Water units</td>
<td>1</td>
<td>100 tonnes</td>
</tr>
<tr>
<td>100 tonnes</td>
<td>Tilapia</td>
<td>100 tonnes</td>
<td>100 tonnes</td>
</tr>
<tr>
<td>100 tonnes</td>
<td>Catfish</td>
<td>100 tonnes</td>
<td>7,800 tonnes</td>
</tr>
<tr>
<td>4,500 tonnes</td>
<td>Clover</td>
<td>7,800 tonnes</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>Sheep (head)</td>
<td>1,300</td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>Warm water</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>Organic fertilizer</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>Waste</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Irrigated land (hectares)</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>Water conservation</td>
<td>67%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Estimated by Aquaculture Consultant Office.

Adopting this strategy, the farm has been able to integrate the production of two different fish crop types each year, as well as arable, animal and biogas production. One hundred tonnes of tilapia can be produced alongside 100 tonnes of catfish annually. The effluent water from the fish farm is used to produce 7,800 tonnes/year of Egyptian clover, which provides fodder for 1,300 sheep/year. Ultimately, the manure of the livestock is used to produce biogas to heat water for the tilapia hatcheries.

Wataneya Fish Farm – Van der Heijden and Verdegem (2009) reported that the commercial tilapia desert farm El-Wataneya Fish Farm began in 1998 on 25 hectares of unused land as an integrated farm producing tilapia, chicken, vegetables (cucumbers, tomatoes, bananas, wheat, peppers, mangos, etc.) and flowers, mainly gladiolas. For crop production, freshwater is used from the Ismailia Canal, which is connected to the Nile River, together with groundwater and fish farm effluent. The only difference between these three sources is that the groundwater is used entirely for fish culture. Water in the concrete fish basins is normally replaced at a rate of 25–35 percent/day but can be as high as 60 percent/day in the latter stages of the fish production cycle. Even though water is already available at a depth of 3 m, the farm pumps water from 70 m. All fry and
nursery tanks are aerated with blowers, while grow-out tanks are equipped with 2 HP paddlewheels which maintain constant levels of oxygen. In terms of profitability, tilapia is on top of the list, followed by bananas, vegetables and flowers.

Another success story is in respect of a farm located to the East of the Suez Canal and occupies in excess of 1600 feddan of previously uncultivated land. The project began more than 12 years ago with the aim of producing organic horticulture and agriculture crops to meet the increasing local and export market demand for organic produce. Horticulture crops grown on the farm include oranges, mango and grapes. Many varieties of vegetables are also produced, including spring onions, baby corn, mangetout peas, green beans, fine beans, sugar-snap, holiday peas and cherry tomatoes. The farm relies on periodic use of Nile water to irrigate horticulture crops and vegetables cultivated in the farm. Farm management practices required the establishment of water reservoirs to conserve water for irrigation during periods when Nile water becomes unavailable. The company developed 8 basins (earthen ponds, lined with synthetic material) as water reservoirs. Total basin capacity has increased this year to store 50,000 m³ of water. Each basin irrigates specific areas of the farm. Effluents from the fish ponds rich in organic waste from the cultured fish are channeled to the arable farm to fertilize the crops.

The idea of the integrated system of agricultural production and aquaculture intensive fish farms:

In this case the fish reared on clean underground water free from any chemical or microbial contaminants and the reclaimed land irrigated by the water effluents loaded with organic fertilizers as materials resulting from the outputs of the fish excreta and their droppings.

Getting the returns parallel to the Egyptian experience (valued integrated system), namely:

- **First yield:** Availability of seed throughout the year by establishing a fish hatchery of Nile tilapia which works throughout the year using a type of heaters for heating water during winter.
- **Second yield:** Availability of fingerlings throughout the year by establishing nursery ponds for breeding fingerlings and thus achieve an abundance of juveniles throughout the year.
- **Third yield:** Availability of broodstocks of Nile tilapia for those interested in the establishment of hatcheries.
- **Fourth yield:** The availability of Nile tilapia with an average (3-4) per kilo of fish throughout the year.
- **Fifth yield:** The production of clean catfish: cultivated on wastewater ponds (broodstocks - fry - fingerlings) as another type of fish, where they fed on waste water of tilapia and the remains of kitchens and thus provide a healthy system where there is no waste permanently.
- **Sixth yield:** Agricultural production: The cultivation of crops, orchards and alfalfa on wastewater fish which helps to increase soil fertility and thus achieve greater organic agricultural crops.
- **Seventh yield:** Animal Production: Breeding sheep and cattle in semi-open system grazing on alfalfa and thus increase soil fertility and also get a product for meat and milk of high quality.
- **Eighth yield:** Biogas project to establish on the waste of sheep and cattle stocked in the project, which helps to produce fuel used as a source of energy in the various activities of the system and also get organic fertilizers sterile as a product of a recent analysis of organic high quality and security free from any contamination of the soil.

**Environmental usual equation:**

Raw materials (operation) = one product + waste polluting
Equation safe environment Egyptian experience (integrated system)
Raw materials (operation) = product + product + product + (zero)
10. CONSTRAINTS FACING TILAPIA AQUACULTURE

- Overpopulation
- Deterioration in genetic quality.

10.1. Overpopulation

A good culture species must be capable of reproducing easily under controlled conditions. The ease with which tilapias reproduce is both a boom and a curse. Tilapia species are very prolific in breeding to the point of becoming nuisance in fish pond culture systems as result of overpopulation leading to serious competition for food and space which retards growth as biological energy are expended on reproduction rather than growth. Reproduction in culture ponds can occur 2 or 3 months after fingerlings are stocked. Ponds quickly become overpopulated with young fish which compete with larger fish for feed. The result is a harvest of relatively small fish unwanted in many markets. As failure of tilapia culture in the past, has often been due to uncontrolled spawning. Development of methods to control tilapia reproduction in ponds was a major milestone in the culture of these species. Several methods have been used for production of all male progeny. There are basically six methods of controlling tilapia populations. These are (1) monosex culture of which single-sex fish are obtained through: manual separation of sexes, hybridization, hormone sex reversal (2) super male (3) culture in cages; (4) high density culture; (5) stocking predatory fish (biological control); (6) triploidy (sterilization).

10.1.1. Manual-sexing

The male have one orifice and the female have two orifices and the female often has a smaller genital papilla. But even under the best conditions and when the sexing done by trained people there is a certain error resulting in some wild spawning in ponds (Photo 28).

10.1.2. Using hybrid crosses

Hybridization occurs between two species of tilapia in order to produce an all-male hybrid population. O. niloticus female and O. aureus male, produces 80-90% males, with the growth vigor of O. niloticus and the cold tolerance of O. aureus. O. niloticus x O. aureus may produce all males depending on the external characteristics and their electrophoretic patterns (photos 29, 30).

Photo 29: Hybrid from O. niloticus and O. aureus.
The advantages of hybridization:

» Producing monosex male population.

» Better catchability- *O. aureus* is difficult to catch by seining. It burrows into the mud and evades the net. So it is hard to harvest without draining the pond. Crossbreeds of *O. aureus* and *O. niloticus* behave like the latter; do not evade the net and easily caught.

» Efficient use of tropic niches: While *O. aureus* feed on the detritus and the ooze at the upper layer of the bottom, *O. niloticus* feed mainly on phytoplankton from the water column. The hybrid also feed like *O. niloticus* and this important in polyculture.

Tolerance of low temperature: *O. aureus* is more tolerant of low temperature than *O. niloticus*. *O. aureus* withstand temperature as low as 9°C, while *O. niloticus* limit is 11-12°C. The hybrid will tolerate to 10°C.

- (Female Red tilapia × Male Nile tilapia) hybrid can be produced and reared at different salinity levels up to 32 ppt as economic value compared with their parents (El-Zaeem et al. 2012).
- Growth rate: Cross breeds grow about 25-30% better than either parent species (hybrid vigor); Hybrid exceeds the parents in performance.
- Marketable color: The color of crossbreed of *O. aureus* x *O. niloticus* is more lighter which is preferred in the marked.
- Hormonal sex-reversal
  - Using mainly methyl testosterone, aromatase inhibitors and estrogenic antagonist were tried.
- Super male YY
- Using cages to rear tilapia
- Stocking predatory fish
- Triploid (experimentally)
- Subjected the egg to an environmental shock.

### 10.1.3. Hormonal sex reversal

Tilapia larvae are said to be sexually undifferentiated for few weeks after hatching. Accordingly, if the tilapia larvae are fed with feeds that are incorporated with male hormone (e.g. 17α-methyl testosterone), the fish will develop into phenotypic male (physically appears and functions as male but possesses the female genotype (XX)); in the same way, if a female hormone is mixed with the feed that is taken by the fish, then the fish will be directed to phenotypic female (physically appears and functions as female but possesses the male genotype (XY)) (Little 1989 and 1993). All those techniques were tried but the only applicable method used is hormonal sex reversal using 17α methyl testosterone.
A study carried out at the department of Fish Diseases and Management, Faculty of Veterinary Medicine, Benha University, Egypt by EL Asely et al., (2007) and Walaa (2012) under supervision of Dr. Shaheen. Where, both steroidal (17 alpha methyl testosterone) and non-steroidal compounds (tamoxifen and letrozol) were investigated for their effectiveness in production of all male tilapia, after using different concentrations and times. It was noticed that the highest growth rate and highest male percentages with the lowest deformity and mortalities were achieved from using MT. While Letrozol and tamoxifen in the diet for 28 days although they may produce high male percentage; they showed higher percentages of intersex and deformity especially in the head region with reduced survivability (photo31). The study also demonstrated that the hormone residue of tilapia fed MT treated food didn’t differ from the control group at 120 days post hatching (El Asely, 2004 and El Asely et al, 2007). In the same respect Abd Al-Hakim, et al, (2012) stated that the use of 60 mg/ kg MT produced statistically higher male sex percentage when done for 28 days post hatch with efficient feed and protein utilization and in turn attaining higher growth performance, survival rates and human safety.

Studies of retention of 17 a-methyltestosterone in tilapia suggested that no more than 10 picograms (pg) of methyltestosterone and its metabolites remained in fillets (Goudie et al. 1986). This was not considered a dose great enough to be of food safety concern. However, little information is available on the possible effects on hatchery workers of handling androgens. A respirator, eye protection, and gloves should be used to prevent contact with the material when it is used in hatcheries.

The US - FDA, through the Investigational New Animal Drugs/New Animal Drug Application (INAD/ NADA) program, has investigated the use of MT hormone for production of all male tilapia. Now even the US government supports the use of reversal techniques by allowing all of the tilapia hatcheries who wish it to participate in what is known as an INAD. This basically means they have the right to put chemicals into the food of the fish that are used for long period without showing any hazards and not yet cleared as being safe, as long as they send results in to the government.
10.2. Deterioration in genetic quality

10.2.1. Improved breeds

Two improved breeds of Nile Tilapia that grow up to 30% faster are helping farmers were developed in West Africa and Egypt to increase the productivity of their fish farms (photo 32). These developments are the result of breeding programs in Ghana and Egypt by WorldFish and partners to improve two strains of Nile Tilapia (Oreochromis niloticus). Nile Tilapia usually takes eight months to reach maturity from the fingerling stage when they are purchased from hatcheries. The ‘Akosombo’ strain, which was bred by selecting the fastest growing fish over eight successive generations, matures in as little as five months, meaning that farmers can produce more fish each year. This is good news for the people of Ghana who according to the World Health Organization rely on fish for up to 74% of their animal protein intake.

WorldFish is working with the Egyptian Central Laboratory for Aquaculture Research (CLAR) and industry players to produce-within two years starting at 2011 a strain of Nile tilapia that grows about 20% faster than existing commercial strains under prevailing Egyptian pond conditions. This new strain will form the nucleus of a long-term national breeding program designed to deliver superior strains of farmed fish.

In 21 January 2014 it has been declared about the New Tilapia Strain driving Growth in Egypt’s Aquaculture Sector (See more at: http://www.thefishsite.com/fishnews/22288/new-tilapia-strain-driving-growth-in-egypts-aquaculture-sector#sthash.ryT0RScx.dpuf)

The strain was developed through a selective breeding programme. The ‘Abbassa Strain’ grows up to 28 per cent faster than the best commercial breed in the country, and is expected to bring much-needed economic, food and nutrition security benefits to millions of Egyptians. Over the last year breeding centers established by the IEIDEAS project have supplied 50 fish farms and 130 hatcheries with the fast-growing strain, and the hatcheries plan to supply at least 2,000 more farms in 2014. These private sector businesses are playing a key role in disseminating the highly productive fish to farmers, who will receive a much-needed boost in productivity.

The IEIDEAS project (mission undertaken in March 2013) to critically review the institutional, policy and regulatory framework for sustainable development of the Egyptian aquaculture sector on behalf of the “Improving Employment and Income through the Development of Egypt’s Aquaculture Sector” (IEIDEAS) project, implemented by WorldFish and CARE and funded by the Swiss Agency for Development and Cooperation (SDC), now entering its third year, is helping to strengthen the aquaculture industry and generate employment for the one hundred thousand men and women who depend on the sector (Hebicha et al., 2013).
10.2.2. Red tilapia

In Egypt production of red tilapia is very modest; based mainly on individual trials. In 2012 the hatchery production of red tilapia fingerlings recorded 0% from both governmental and private fish hatcheries (GAFRD, 2012) table (11).

**Table 11: Red tilapia fingerlings reached to ZERO%**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Total</th>
<th>Private Hatcheries</th>
<th>Govermental Hatcheries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Marine water</td>
<td>Fresh water</td>
</tr>
<tr>
<td>Gilthead seabream</td>
<td>2.260</td>
<td>2.000</td>
<td>-</td>
</tr>
<tr>
<td>European seabass</td>
<td>1.796</td>
<td>1.600</td>
<td>-</td>
</tr>
<tr>
<td>Shrimps neil</td>
<td>5.700</td>
<td>5.700</td>
<td>-</td>
</tr>
<tr>
<td>Red Tilapia neil</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tilapia neil</td>
<td>242.558</td>
<td>-</td>
<td>191.000</td>
</tr>
<tr>
<td>Sole, common</td>
<td>0.250</td>
<td>0.250</td>
<td>-</td>
</tr>
<tr>
<td>Common carp</td>
<td>89.200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Silver carp</td>
<td>23.608</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grass carp</td>
<td>44.226</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mullets neil</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>410.598</td>
<td>9.550</td>
<td>191.000</td>
</tr>
</tbody>
</table>


Red tilapias are genetic mutants selected from tilapia species in the genus Oreochromis sp. The first reported red tilapia hybrid was produced in Taiwan in the late 1960s and was a cross between a mutant reddish-orange female O. mossambicus and a normal male O. niloticus and is called the Taiwanese red tilapia (Galman and Avtalion, 1983).

Some strains of red tilapia are salt water tolerant. Oreochromis mossambicus is known to tolerate full strength seawater (Green, 1997) and red tilapia with Mozambique tilapia heritage can be cultured in full strength seawater. Nile tilapia can be adapted to 25 to 30 g/l saltwater but growth is inhibited in salinities above 15 g/l (Popma and Lovshin, 1996). Nile tilapia is reported to spawn in salinities above 20 g/l but egg hatch is reduced in salinities above 10 g/l compared with hatch rates in freshwater and 5 g/l salinity (Watanabe et al. 1984).

Major disadvantages of red tilapia culture are the difficulty in for spawning some strains of red tilapia and the low viability of red tilapia eggs and fry, Hulata et al. (1995). Survival of all-red tilapia hybrids was lower than survival of O. aureus × O. niloticus hybrids during the nursery phase. The reason for the poor reproductive
performance of the red Egypt *O. niloticus* x *O. aureus* was thought to be caused by behavioral differences during courtship that limited spawning. Low survival of juvenile red tilapia hybrids compared with wild-colored hybrids was because of bird predation on the easily spotted red fish.

Red tilapia are grown to market size using a variety of culture techniques similar to those used to culture pure-line tilapia species. Red tilapia are grown in fresh and saltwater with cages, concrete tanks and earthen ponds using semi-intensive and intensive systems (Watanabe et al., 1997); El Gamal (1987) stated that the Nile hybrids grew faster than the Nile tilapia. Normal and red colored blue hybrids averaged 209 and 181 g while normal and red colored Nile hybrids average 281 and 240 g at the same rearing period.

Lovshin (2000) concluded that consumers from many locations round the world demonstrate a clear preference for red colored tilapia over the darker colored Nile tilapia. Unfortunately, in most culture situations red tilapia does not perform as well as Nile tilapia. Female spawning success in some red hybrid strains is lower than Nile tilapia and survival of eggs and fry is almost uniformly lower in red tilapia than in Nile tilapia.

Juvenile and adult red tilapia is highly susceptible to predation by birds. Red tilapia typically swims just under the water surface where they are easily seen by birds. The culture of red tilapia in large ponds may not be possible without covering the ponds with expensive netting or shooting the birds, many of which are protected by law.

Red tilapia is more passive during harvest and is not as adept at escaping the seine by jumping over or swimming under it. Red tilapia is also reported to be easier to transport alive for long distances. Nile tilapia injures themselves by swimming and jumping wildly during loading into and harvest from the transport tank. Similar behavior by Nile tilapia during sampling and partial harvest from cages also results in injury. Injured fish have a higher incidence of mortality after handling.

Red tilapia product form on sale must have the skin on to take advantage of the red coloration and attract consumers. Skinless product forms from red tilapia, such as fillets, have no market advantage over the same product form from a Nile tilapia (photo 33).

The choice of red tilapia or Nile tilapia for culture will depend mainly on marketability and water salinity.

![Photo 33: Red tilapia with the skin-on is attractive and easier to market than the Nile tilapia. With the skin-off, little difference is noted between the red and Nile tilapia.](image)

### 10.3. Overwintering

Tilapia fish can survive in 12-40 degree centigrade temperature but grows well between 16-35 degree centigrade temperature and mortality in ponds occurs at 9-10 oC. Tilapia Overwinter greenhouses may be
placed in earthen ponds whereas plastic covers go well below water surface but not reaching pond bottom. The area beneath greenhouses will be protected against cold winds and act as shelters to tilapia. In sunny days the fish can move freely under the plastic cover photo (34).

![Photo 34: Green house covering part of the pond.](image-url)

### 10.4. Filamentous algae
Because tilapia ponds are shallow and the fish does not steer the water consequently the sunlight penetrate much deeper through the water column leading to production of heavy algal. The blooms can consume all available oxygen either during nocturnal respiration or by increasing biochemical oxygen demand (BOD) if blooms suddenly die. Some algae are able to produce specific toxins able to kill fish.

The sticky nature of the bloom may occasionally coat the gills and physically suffocate the fish, when the pond contains excessive concentration. The problem can be overcome by partial water exchange, algaecides or biocontrol (introducing about 20% of carp).

### 10.5. Off-flavor
- Depuration systems by using clean water for fish rearing would help to remove the muddy off-flavor or “earthy smell” caused by geosmin.
- Control of blue-green algae
- Production in system with limited access to benthic algae

The Red tilapia hybrids, produced first time in Taiwan through the interspecific cross of *O. mossambicus albino* and *O. niloticus*, gives desirable features of tilapias (Anon. 1984).
- The use of the recently developed improved tilapia strains (GIFT, GMT) Improved breeds of tilapias from breeding programs on selection and sex control.
- The lack of attention given to marketing and other business aspects is also a constraint to successful commercial farming of tilapias.
II. OBSTACLES THAT IMPEDE PROGRESS OF AQUACULTURE AND METHODS OF HANDLING:

11.1. Land availability
For example at the province of Kafr el –Sheikh, the main producer of aquaculture, between 30-40 % of the volume of Egypt fish production, and the nature of the coastal province, is granted by this feature., that is issue of land availability. According to official statistics of the province, the area of fish farms is approximately estimated at 50 thousand feddans. The number of people working in the field of fisheries in Kafr El-Sheikh reached about 750 thousand families, and they are threatened with displacement in the absence of official control on the reasons for the collapse of the industry.

The limited space available for aquaculture is considered a scalable obstacle because it leads to a rise in the price per feddan for the renter annually. To overcome this problem more practices had been performed, such as

- Intensive farming which means raising the productivity per feddan vertically, by increasing productivity per cubic meter.
- Establishment of fish farming in the desert depending on the ground water especially in the area of Wadi el-Natrun.
- Intensifying farming in floating cages over the water in banks, lakes and canals.
- The random designs of some fish ponds impose a major obstacle toward the industry. The main reason for this problem is that most of these farms designed in any form as temporary Farms,
- The collapse of bridges ponds, because it leads to the escape of fish farms.

11.2. Feed availability
- High prices of fish food, which caused some farmers to stop farming of tilapia and instead shifted their business to raise fishes which rely only on natural food such as silver carp and bighead carp. The artificial food costs more than 65 % of the total running costs in fish farms. The price per ton inside the licensed factories ranged between 3700 and 5000 pounds, because its components have been imported from abroad and their prices associated with higher or lower value of the dollar. Reduction of taxes and customs duties on raw materials may help to solve the problem.
- Diesel crisis doubled from the fish production crisis, because the farm owners rely primarily on irrigation machines to raise water to their farms. This is in addition to fueling cars used for transferring the fish to the public markets or to the retail market for sellers. So the government must, in the coming period, distribute the diesel fuel by the agricultural card holding for fish farmers.
- The institutions of fisheries and the government should punish those who engage in monopoly of raw materials for food taking the advantage of the weak control and relaxation in the implementation of laws.
- Finally the case of instability as there is a competition between the cultivation of agricultural crops and aquaculture where some farmers converted their agricultural lands to fish farms in the hope of money gains realized from this project, especially as the acre of fish provides a 20 thousand Egyptian pounds, a sum which cannot be provided from acre of agricultural land.

11.3. Operational services
- Diesel crisis doubled from fish production crisis. The farmers depend primarily on irrigation machines to raise water to their farms. In addition, fueling cars to transfer the fish to the public markets or to the retail market for sellers. So that the government in the coming period must distribute the diesel fuel through the agricultural card holding by the fish farmers.
- The institutions of Fisheries do not support in any form. They should call the government to punish those who engage in the monopoly of raw materials for feed and who impose a part in raising prices, taking...
advantage of the weak control and relaxation in the laws enforcement.

• Finally the case of instability as there is a competition between the cultivation of agricultural crops and aquaculture where some farmers converted their agricultural lands to fish farms in the hope of many gains realized from this project, the feedan of fish crop provides a 20 thousand Egyptian pounds, a sum which cannot be provided by any feedan of agricultural land.

11.4. Fish diseases
Fish diseases are sources of huge threat facing aquaculture industry. Fish coexist with microorganisms in the aquatic environment but when they exposed to the pollutants they become immunocompromised and more susceptible to infection by those opportunistic microorganisms. In Egypt the high industrial and agricultural effluents drainage in the natural waterways put the fish under stress and become vulnerable to catching diseases.

Global estimate of disease losses to aquaculture by World Bank (1997) was estimated at USD 3 billion. The current estimates suggest that between 1/3 and 1/2 of farmed fish and shrimp are lost due to poor health management before they reach marketable size (Tan et al. 2006).

Fish diseases may be:
• Infectious diseases (parasitic, bacterial, fungal and viral)
• Non infectious diseases (nutritional deficiency, environmental and pollutants, intoxication- toxins and algae)

11.4.1. Parasitic diseases
In Egypt, there are a long periods of optimum warm weather that enable parasites for more production that’s explained why the prevalence of parasitic diseases is about 80% of fish diseases (Eeissa, 2002). Ectoparasitic diseases are widely distributed among wild and cultured O. niloticus at Egypt (Shaheen, at al. 2001).

Trichodiniasis
Trichodiniasis is a disease caused by protozoan parasite of the genera trichodina and trichodinella (Fig. 19, 20). Infested fish show grayish blue-like coating disintegration of membranous protein of the fins and may infest the spleen. The gills may show destruction of the bronchial epithelium in fry especially in those subjected to malnutrition. The parasite causes high mortality in fish hatcheries for the fingerlings. Copper sulphate 1-4 mg/L for 1 hour may help in control.

Monoginiosis
Monoginiosis is caused by monogenetic trematode from the most important helminth parasites of fishes (cold water, tropical and marine fishes). They include hundreds of species. The most important groups is the Dactylogyrids parasitizing gills (Gill flukes) Fig. (21), and Gyrodactylids parasitizing skin and gills mainly skin (skin flukes). Skin Flukes caused by Gyrodactylus species of class trematoda, order Monogenea. The flukes feed on the blood and epithelial cells and in doing so they cause considerable damage to the skin of the fish. Gill Flukes Dactylogyrus is a monogenetic trematods belonging to the family Dactylogyridae.

In skin flukes, the fish become dull and feeble. The fish rub themselves against any object. The skin becomes much slimy and shows small blood spots. Breathing generally is increased in frequency even in cases where the gills are not affected.

In gill fluke, partial suffocation due to loss of gill functions. Increased breathing frequency and the gill cover
widely opened. Some parts of the gills often become protuberant and parts of which are covered with a cloudy film consisting of slime and destroyed epithelial cells.

If only the skin is affected the prognosis is not so bad, but if the gills are affected recovery is only possible with early and strong treatment before the victims become weak. Formalin 250 mg/L bath for 1 hour can be used.

**Figure 19:** Trichodina from the spleen.  
**Figure 20:** Monogenia and trichodina the skin

**Digenetic Trematodes**

Digenetic trematodes are found in fish either in the form of larvae (the most common infestation) or as a sexually mature parasite. In case of larvae they are usually found as encysted metacercaria in the subcutaneous tissue or internal organs.

It is not easy to eradicate adult trematodes or their metacercariae from fish. However, control of snails and aquatic birds together using a suitable therapy may improve the case.

**Yellow Grub disease** The disease is worldwide affecting many kinds of freshwater fishes caused by Clinostomum sp. (digenetic trematode). The disease in tilapia is commonly known and caused by Clinostomum tilapae. It is characterized by presence of small creamy-colored nodules or cysts on the body, head and fins of the infested fish (Fig. 22, 23). The infective stage is the larval stage (encysted metacercaria) of the digenetic trematode, Clinostomum tilapae. They appear as small creamy-colored nodules, ranging from pinhead size up to 2.5 mm. Depending on their age, in the body, head and fins numbered from one to more than one hundred. Discomfort only occurs in fish invaded with large number of cysts or in young fish. In some cases distended abdomen may precede the appearance of the cyst. The nodules appear three weeks post infestation and takes seven weeks before reaching their full size.

Basically there is no therapeutic treatment for yellow grub disease and prevention depends mainly on breaking the life cycle.
Internal parasitic diseases

Climatic changes not only have a direct effect on the parasite species but also indirect effects through changes in the distribution and abundance of their intermediate and final hosts. Thus the parasites could be used as biological indicators for the environmental impact and changes.

In Egypt, there are long periods of optimum warm weather that create the environment for increased multiplication of parasites which explains the prevalence of parasitic diseases is about 80% of fish diseases. Internal parasitic diseases have no pathognomonic clinical signs in the diseased fishes. Cultured Oreochromis niloticus were less exposed to internal parasitic diseases than wild ones.

Internal parasitic diseases (Fig. 24, 25, 26) may reduce fish production by affecting their normal physiology and have detrimental effects on the function of affected organs. In addition, they may induce health hazard on human and other vertebrates that consume such infested fish.

Contracaecum Species

Larval stages of the Contracaecum species infect freshwater fishes are usually found as adults in fish-eating birds, such as cormorants and pelicans.

Elimination of final hosts (bird or mammal) and invertebrate intermediate hosts from the aquaculture site may reduce and, possibly, eliminate infection.

Molecular identification of Contracaecum species may be a promising result for diagnosis of the disease and need further studies (Aya-Matter, 2014). She noted the presence of the parasite in abdominal cavity of fish may pose repulsive appearance as well as public health concern.
11.4.2. Bacterial diseases

*Motile aeromonas septicemia (MAS)*

It is an acute, subacute, chronic and septicemic disease of cultured fresh water fish characterized clinically by reddening of skin and fins, swelling on the skin and finally ulcer formation. Aeromonas hydrophila, the etiological agent, is the most common bacterial species isolated from apparently healthy and diseased tilapia.

Tilapia infected with MAS shows lethargy, off food, swimming near the surface with loss of reflexes. There are erythema and hemorrhages on the skin, opercula, mouth, anal opining and at the base of the fins, with degenerated fins. Erosions and ulceration were also observed in the skin (Rasmia-Abu Leila, 2005) Fig. (27, 28, 29 and 30).

The organisms usually grow on the primary medium brain heart infusion agar. On the selective Rimler–Shotts agar (R-S media) it shows profuse growth and appears within 24 to 36 hours after inoculation between 20 and 22°C.

Many antibiotics are effective from which, oxytetracycline and sulfa drugs are approved ones. Oxytetracycline used in the food at the rate of 55 mg per kg of fish per day for 10 days. Sulfamerazine used at 264 mg per kg of fish given in the food for three days, followed by 154 mg per kg of fish per day for 11 additional days.

Some species of aeromonas may cause many human health hazards Streptococcusosis.

In Egypt, it was recorded in Nile tilapia as one of the most common diseases causing dangerous outbreaks (Badran, 1994; Ebtsam, 2002 and Eman et al., 2007a & b).

Clinical examination of infected O. niloticus in the Faculty of veterinary Medicine, Benha University, Egypt showed (Fig. 31), haemorrhagic spots on the external body surface particularly on the operculum, base of the fins and mouth edges (a & e), black coloration of the skin, uni- or bilateral exophthalmia (b & f), corneal turbidity, skeletal deformity (c) and abdominal distension. Internally the lesions recorded were congestion or paleness of liver with distended gall bladder and gray white necrotic lesions in liver. Kidneys and spleen were
congested and enlarged (d). In some cases ascetic fluid in abdominal cavity was Abscess-like swellings under the skin were characteristically observed among fish infected via skin scarification (g) later on these swellings erupted and release pus-like material extended around the site of inoculation (h) at different areas on the skin (Eman, 2007a).

Figure 31: Eman 2007a

Streptococcus spp. grows well on brain heart infusion agar, tryptic soya agar, streptococcus selective agar and blood agar. They appear as Gram-positive cocci arranged singly or pairs or in chains either short or long according to Streptococcus spp., Fig (32)

Molecular characterization of St. faecalis and St. faecium using SDS-PAGE pattern of whole cell protein showed several protein bands of different molecular weights ranging from 21.0-229.9 KDa. The more common bands recovered among the tested strains were 35.0 and 31.0 KDa (Fig. 33).

Eman et al., 2007b.
The selected antibiotics were chosen based on the in vitro sensitivity test. Erythromycin, oxytetracycline (Eman, 2007b). Recently florfenicol is considered the most effective approved antibiotic used for treatment of streptococcosis in Nile tilapia and its residue in musculature reaches to below the maximum recommended level (1µg/g) at 7th day post treatment (Abd.El-latif et al., 2013).

**Columnaris disease**

Columnaris disease, caused by *Flavobacterium columnare* is one of the oldest known fish diseases in the world, and has been for decades a significant problem in many warm water fish species. It affects a wide variety of fish wild, cultured and ornamental fish in both freshwater and brackish water. *Flavobacterium* spp. have been retrieved from diverse ecological niches such as soil, sediment, freshwater and marine water ecosystems.

Clinical examination of the collected Nile tilapia revealed the presence of number of external clinical abnormalities including, apical gill lamellar necrosis, marked skin ulcerations at the frontal head region (fig.28); typical hole in the head like lesion with marked liquefaction of the underlying frontal tissues; marked signs of fin rot with/without corneal opacity.

Clinical records also revealed that more than 75% (38 out 50 fish) of the examined Nile tilapias were associated with head cysts that usually progress to frontal ulcers, then penetrate deeper in the skull to form hole-in-the-head like lesion (Fig.34 & 35). Isolation and molecular identification revealed positive results (Fig. 36 & 37). Microscopic examination of unstained wet mounts made from these lesions revealed the presence of piles “hay stalks” of very long bacteria presumptive for *F. columnare*. Giemsa stained smears from the head lesions revealed the presence of very long rods 8-15 µ (Eissa et al., 2010).

![Figure 34 &35: O. niloticus infected with *Flavobacterium columnare* showing skin ulcerations. Rasmia-Abu Leila (2014).](image)

![Figure 36: F. columnare on cytophaga agar media](image)

![Figure 37: F. columnare PCR identification](image)
Oxytetracyclin and many immunostimulants (punica peel extract (PPE)) were tested against F. columnare approved that the former was superior to control the columnaris infection with higher survival rate.

Experimental trial of vaccination was carried out but does not apply in fish ponds.

Preparation of Formalin-killed bacteria

\[
\text{F. columnare} \rightarrow \text{Hsu-Shotts media} \rightarrow \text{Hsu-Shotts broth} \\
\text{Resuspension in PBS} \rightarrow \text{Harvestation by cooling centrifuge} \\
\text{0.2 formalin} \rightarrow \text{Washing with PBS}
\]

Preparation of Punica Peel Extract (immunostimulant)

\[
\text{Pomegranat peel} \rightarrow \text{Blinded to powder} \rightarrow \text{Dissolved in ethyl alcohol} \\
\text{Evaporation of ethyl alcohol} \rightarrow \text{filtration} \\
\text{lyophilization} \rightarrow \text{Deep freezeed}
\]

**Vibriosis**

Vibriosis is a systemic bacterial infection of primarily marine and estuarine fishes. It is a major cause of mortality in marine culture operation; sometimes outbreaks also occur in freshwater species. In Egypt Vanguillarum and V.parahemolytica were isolated from clinically diseased O. niloticus showing high mortality rate (Amany et al., 2000 and Manal-Hefny, 2008). The disease can cause significant mortality (=>50%) in fish culture facilities once an outbreak is in progress. Clinical signs revealed general infection of the entire organism (acute form) (Fig. 38, 39) and local infection especially of the (skin, musculature and intestine) in chronic form.

![Figure 38: O. niloticus infected with vibriosis showing erythema](image)

![Figure 39: O. niloticus infected with vibriosis showing detached scales and fin rot](image)

The pathogen may be readily isolated from infected tissue. The kidney is probably the best organ for isolation on: 1) Tryptone soy agar TSA. 2) Nutrient agar. 3) Brain heart infusions agar supplemented with sodium chloride 0.5-3.5%. 4) Sea water agar. 5) Thiosulphate citrate bile salt sucrose agar T.C.B.S. Incubation period at 15-25°C for 7 days.
In confined, heavily stocked, commercial systems, Vibrio disease outbreaks can precede rapidly. Therefore, prevention is essential to any management scheme. As Vibrio species are believed to be opportunistic, conditions, which favor a disease outbreak, are often caused by environmental stress, which can be avoided. Poor nutrition or water quality, improper handling, overcrowding, and the presence of other disease-causing agents will all increase the chances of contracting a Vibrio infection. Parasites are of special concern, as they often cause damage to fish tissue, creating an ideal location for Vibrio infections to begin.

Exposure to copper (>30 µg/m) or iron (>10 µg/m) increases susceptibility to vibriosis. Treatment must be made as early as possible by using oral antibiotics; clinically affected fish don’t eat and cannot be treated.

- Oxytetracycline 75mg/kg of fish/day for 10 days.
- Sulphonamides (sulphamerazine) 170/200mg/kg of fish/day for 14 days.

11.4.3. Fungal diseases:

**Saprolegniasis**

Is an integumentary mycosis of freshwater fishes and fish eggs. Brackish water fishes may be affected but salinity above 2.8% limits their distribution. Temperature has a significant effect on the development of the infection as it mostly occurs in winter below 15°C. While infections following trauma occurs at any temperature.

Focal gray-white patches on the skin of fish, which appear as cotton wool like tufts when examined under water, the hyphal filaments extend out into the water (Fig. 40). Skin, gills, fins and eyes are mostly infected (Shaheen and Amany, 1999). Finally the fish appears as if it wrapped with cotton.

In incubating fish eggs Saprolegnia usually establishing itself first on dead eggs and then extending everywhere to colonize the neighboring healthy ones. The disease causes high losses in fish hatcheries.

The disease can be diagnosed from the clinical signs, when the fish still alive, Microscopic examination of wet mount preparation, Fig. (41 and 42) and isolation of the fungus; initially in sterile water on bait e.g. hemp seed then subcultured on Sabauraud’s dextrose agar (Shaheen 1986).
Control can be carried out through improvement of the environment, removal of moribund and dead fish, proper feeding and avoidance of crowding which lead to skin damage (traumatic, bacterial, viral, parasitic etc.). In fish hatcheries removal of dead eggs must be carried out regularly.

Several chemotherapeutics may be used as follows: * Formalin 250 mg /L for 1 hour bath; potassium permanganate

**Ichthyophonosis**

Systemic granulomatous infection of freshwater, estuarine and marine in temperate and tropical habitats. Caused by Ichthyophonus hoferi, which is both internal and obligate pathogen. The clinical signs vary according to the fish species. In tilapia there is no pathognomonic lesion. Description of the internal lesions of the organism, isolation on Sabouraud’s agar with 1% calf serum and histopathological preparations were illustrated in Fig. (43). There is no available treatment.

![Figure 43: Ichthyophonus hoferi; a) light grayish nodules mostly detected in liver b) wet mount showing multinucleated cysts, c) fungal growth on Saboroud’s agar with 1% calf serum d) hyphal filaments stained with lacobophenol cotton blue showing the hyphal bodies e) spherical quiescent or resting stage appeared as spherical cyst having a thick double walled surrounded with connective tissue capsule f) thick walled resting cyst containing an amorphous disorganized mass (Shaheen and Easa, 1996 & Amany A. Abbass et al., 2003).](image)

**Branchiomycosis (Gill rot)**

Fungal disease of fish known as gill rot, caused by Branchiomycetes spp. fungi, characterized by areas of infective necrosis in gills giving them the marbling appearance. Microscopic examination revealed thick hyphal filament containing translucent material (Fig 44).

![Figure 44: Thick hyphal filament containing translucent material of Branchiomycetes sp. Shaheen unpublished data.](image)

High loading of organic matter in highly enriched pond with nitrogenous organic compounds resulting, for example, from the addition of various types of manure (eutrophication) is the most prominent predisposing factor.
Outbreak of the disease would occur during the warmest months.

Branchiomycosis appears suddenly and often has a rapid course with losses about 30-50% within 2-4 days. The disease caused high losses among cultured tilapia at Egypt in 2013.

The sudden onset and rapid course of the disease may lead to high mortalities before the treatment could be instituted, so attempts for prevention mostly preferred as following:

- Increasing water exchange in the pond.
- Controlling the addition of fertilizers.
- Addition of copper sulfate in four treatments 2-3 kg/hectare, at monthly intervals starting in mid-May and ending in mid-August (0.3 mg/L), so that its use and dosage depends on the water quality and the species of fish to be treated.
- Addition of CaO (quick lime) 150-200 kg/hectare, at 2 weeks intervals during the summer and daily during an outbreak, the pH should be monitored and not exceed 9.0.

If an outbreak occurred the dead fish must be removed and burned in a lime pit (burying and burning). Feeding of fish should be stopped and the ponds must be drained, dried and disinfected with quick lime.

11.4.4. Environmental diseases

**Brown blood disease:**
This disease is usually occurs as result of accidental releases of ammonia-rich fertilizer during transport and livestock waste (from barnyards, feedlots, pastures, and rangeland). Also residential and urban, household use of ammonia-containing cleaning products, on-lot septic systems, and improper disposal of ammonia products may contribute to nonpoint pollution. Degradation of uneaten food and industrial effluents may be the principle causes in Egypt. The high mortalities occur due to formation of irreversible methemoglobin (Fig. 45).

![Brown blood disease](image)

**Pollutants, Intoxication - toxins and algae:**
Pollutants range from agrochemicals to heavy metals to human waste products. Though pollution in the Nile River is certainly a large concern, it should be noted that much of the river water is acceptably healthy and free of toxins. It is only in “black zones” near major drains that the water becomes unhealthy. These persistent organic pollutants (POPs) can persist for long period, travel for long distance, bioaccumulate in animal tissues and having lipophillic. Moreover, biomagnifications of these chemicals usually happen through the food chain (photo. 46).
That is why tilapia is a miracle fish? As it feeds at lower level food chain (phytoplankton & zooplankton) where the pollutants at a very low levels. In addition the fish has a little amount of fat in its musculature tissue where the persistent organic pollutants (POPs), the dirty dozen, bioaccumulate. Besides, the exposure time for those pollutants is short in this fish because it reaches the marketable size at short period Photo (46).

Organophosphorous insecticides such as malathion and dimethoate, are more frequently used in Egypt due to their highly effectiveness for controlling agriculture pests but it has been found that they may cause endocrine disruption for the fish.

This is illustrated by the PhD study in the department of fish diseases and management, Faculty of Veterinary Medicine, Benha University, Egypt, under supervision of Dr. Shaheen about the effect of malathion and dimethoate on the reproductive performance and growth of O. niloticus using many of biomarkers as endpoint of endocrine disruption such as sex steroid hormone (testosterone and 17β-estradiol), gonadosomatic index, hepatosomatic index and histological examination of gonad (Eman, 2011).

Results revealed that fish exposed to pesticides exhibited a variety of reproductive problems such as abnormal gamete, reduced fecundity, poor semen quality, low hatching rate and low survivability.

Gonadosomatic index and hepatosomatic index for both females and males treated experimentally either with dimethaote or malathion showed significant decrease at 120 days. Histopathological examination of gonads revealed atretic oocytes and degeneration and decrease in diameter of seminiferous tubules with complete absence of germ cells lining seminephrous (Eman et al., 2011).

There were wide difference in the number of the detected pesticides between pond water samples and that detected in the musculature tissue which reached to 6 and 18 pesticides respectively (Eman et al., 2012). This difference may be due to microbial degradation which analyzes organic pesticides as part of their food or mineralization of pesticides to carbon dioxide, ammonia, water and inorganic salts (Muller and Korte, 1975) or Photodegradation by (thermophilic temperatures, oxygen and hydrogen peroxide) that accelerate pesticides degradation (Muszkat et al., 2002). In addition, high density of phytoplankton in water could absorb a high quantity of most pesticides in the water (El-Nemaki et al., 2008).

11.4.5. Disease control

The disease spectrum may vary a great deal on a global basis depending on the farming conditions, fish species
and status of infectious agents in fish within different regions of the world (Håstein, 1988).

**Chemotherapeutics:**
Various chemotherapeutics have been used to treat bacterial infections in cultured fish for the last 20 years. However, the incidence of drug-resistant bacteria has become a major problem in fish culture.

Control and prevention of diseases, in any country, should be carried out taking into account the better management practices and the biosecurity measures based on the international principles.

**Biotherapeutics:**
- substances or supplements administered to obtain a specific result
- Also called “nutriceuticals” or “Functional foods”

**Examples:**

**Probiotics:**
Probiotics consist of health-promoting bacteria (friendly bacteria) that improve the balance of organisms in the intestines by selectively suppressing harmful bacteria. Although the means by which probiotic bacteria work are not completely known, they may: 1) modify the local bacterial community in the intestines, or 2) insure the improved use of feed or by enhancing its nutritional value, or 3) improve the response of the bird toward disease, or 4) improve the quality of the environment.

**Prebiotics:**
Refers to a group of natural sugars such as oligosaccharides (‘oligo’ = little, scant or few; ‘saccharide’ means sugar) that are resistant to digestion by the host animal or bird but are used exclusively by specific probiotic organisms, allowing them to compete with and thereby exclude disease-producing organisms in the intestines. Thus, prebiotics are nutrients for probiotic organisms. This may be another role for sugars such as glucose or fructose, in addition to the quick source of energy they provide for the birds themselves. One commercial product available for pigeons in North America contains mannan-oligosaccharides, but others such as fructo-oligosaccharides are also available.

**Immunostimulants:**
Immunostimulants are chemical compounds that aid in bolstering the immune system by activating white blood cells, and thereby may render animals more resistant to infections by a variety of infectious agents. Included among these compounds are vitamins, trace minerals, fatty acids, glucans, yeasts, and others such as lactoferrin, chitin (which makes up the hard outer skeleton of creatures like lobsters and crabs), levamisole, probiotics, Spirulina, etc.

**Vaccination strategy:**
The term vaccination strategy has been defined to include the decision as to which diseases to vaccinate against, as well as the vaccine type, vaccination method, the timing of vaccination and the use of revaccination (Toranzo, 2009). Likely it is the best-known method of specific immunostimulation, whereas the use of the several other compounds just mentioned, are examples of non-specific or general immunostimulants.

In Egypt many prebiotics, probiotics and/or immunostimulants as water and food additives are utilized alternatives for the classical antibiotics. Also some experimental trials had been carried out on development of some bacterial fish vaccines but do not enter into practice in the fish farming protocol up till now.
12. **REGULATIONS FOR DISEASE CONTROL**

There is no information on specific provisions on fish disease control.

For countries lacking the necessary legal framework for disease control in fish farming, the OIE International Aquatic Animal Health Code and Diagnostic Manual for Aquatic Animal Diseases (OIE, 1995) may be used as guidelines until specific legislation has been established.

12.1. **Surveillance**

Surveillance of fish means continuous examination of a given population to detect the occurrence of diseases that will be subjected to control purposes and that may be based upon random sampling and testing of the population. Disease surveillance and monitoring is necessary to obtain evidence on whether a country or a region is free from a disease or a disease agent. So that the Veterinary Services or other competent authorities may provide evidence on freedom of reportable diseases, it is necessary to have a national surveillance and control programme. Such a programme must be based upon legislative framework (Baltar, 1994).

12.1. **General drug legislations**

Law No 4/1994 generally prohibits the handling (including the collection and storage, transportation, treatment and disposal) of hazardous substances, which include pesticides, fertilizers and pharmaceutical substances, unless a permit has been issued by the competent body according to the type and use of hazardous substance and waste.

13. **HUMAN RESOURCES**

The people involved in aquaculture can be divided into four groups. The first are the land owners and those with Government issued land lease contracts for traditional fish farms. The total number of people involved in this type of activity has been estimated to be between 37,000 and 43,000 persons. The second group includes people working in fish hatcheries, cage farms and intensive pond aquaculture. Estimate a total of 25,000 persons. The third group includes staff working at Government run hatcheries, fry collection stations, juvenile production facilities and fish farms. The total number of governmental employees working with aquaculture in the field is approximately 1,000 persons. The fourth group includes consultants, feed mill staff, engineers, veterinarians, transport, processing and other support activities estimated to be 540 persons.

The total labor at Egypt estimated as 160,000 people who are directly and indirectly employed in aquaculture in 2007 (FAO, 2010).

14. **TECHNICAL TRANSFER & EXPERIENCE EXCHANGE**

- Egypt is a leader in freshwater aquaculture, while Vietnam is very developed in mariculture. The two countries are an ideal match (for technical transfer) as both shares a similar economic and offer solutions that do not rely on high technology. While Egypt has extensive experience in freshwater pond culture and tilapia breeding, Vietnam has over two decades of experience in mariculture.
- Two improved breeds of Nile Tilapia that grow up to 30% faster are helping farmers in West Africa and Egypt to increase the productivity of their fish farms. These developments are the result of breeding programs in Ghana and Egypt by WorldFish and partners to improve two strains of Nile Tilapia (Oreochromis...
niloticus), an economically important fish that is native to much of Africa, (Ahmed Ibrahim, 2012). The Akosombo strain of Nile tilapia grows about 30% faster than other farmed tilapia currently being cultured, enabling fish farmers to harvest them after six months instead of the usual eight months needed for the non-improved stock. The Akosombo strain, which also has a higher survival rate, continues to attract the attention of fish farmers and hatchery managers across the Volta Basin.

15. **INSTITUTIONS OF RELEVANCE TO THE AQUACULTURE SECTOR, AND THEIR ROLE**

**Government institutions:**
1. Ministry of Agriculture and Land Reclamation (MoALR), overall of the sector, setting policy, legislations (decrees, laws, regulations)
2. General Authority for Fish Resource Development (GAFRD); licensing of all fish farms and hatcheries, leasing of land within 200 m of lakes, data collection, training, capture of wild fry, designation of suitable aquaculture areas, running of governmental hatcheries and feed mills.
3. General Organization for Veterinary Services (GOVS); certification of food safety for export of fishery products, supervising, revising and enforcing conditions and procedures pertaining to exporting fish and marine products.
4. Central Laboratory for Aquaculture Research (CLAR); National Institute of Oceanography and Fisheries (NIOF), various Universities and worldfish; Fisheries research and extension.
5. Ministry of State for Environmental Affairs; implementation of legislation. To obtain a license, fish farmers have to obtain the approval of the Agency after submitting an EIA study.
6. Ministry of Water Resources and Irrigation (MoWRI); To obtain a license, fish farms need to obtain approval of the Ministry, represented by inspection departments affiliated with the Ministry.
7. Other Ministries; e.g. Ministry of Archaeology, Ministry of Tourism, the Authority for Shore Protection, and Border Guard (affiliated with the Ministry of Defense).

**Sector representation**
1. Union of Aquatic Cooperatives (UAC)
2. Egyptian Fish Producers and Exporters Association (EFPEA)

In addition to these key institutions it should be noted that Egypt is divided into 26 governorates, with each governorate headed by a Governor appointed by the President. Local government establishes and runs all public utilities, provides services, and designates industrial areas. Local Councils work closely with local government. Thus governorate and local council offices also have a bearing on the aquaculture sector (Macfadyen, G. et al. 2011).

16. **THE MOST IMPORTANT LAWS AFFECTING WATER USE AND AQUACULTURE**

- Law 48/1982 of Ministry of Environment that aim to protect the quality of inland water.
- Law 124/1983 that gives the right to first use of irrigation (Nile) water only to domestic and agricultural purposes and for fish hatcheries. Fish farms (grow-out) are allowed to use drainage water and brackish water (This brings the risk of accumulation of agrochemicals in farmed fish). Use of groundwater from dessert land is part of land use permit issued by MWRI. The permit to use groundwater is related to status of local aquifer.
- Most important regulation affecting land use is Law 124/1983, which states that only fallow land can be
used for fish farming. Resolution 70/1986 by GAFRD makes this more explicit by stating that only sterile land and land not fit for crop production can be developed into fish farms. The objective of this law is to protect ‘old’ agricultural land from conversion to other uses but it poses complications to the rotation of aquaculture and agriculture, such as the growing of cereal crops on the bottom of fishponds during the winter season. When considering water use in fish farming, the volume should be considered in relation to the kg of fish that will be produced.

Comment on this law:
Peter G.M. van der Heijden (July 2011) on a workshop about integrated aquaculture– agriculture in Egypt, towards more efficient use of water resources). Speakers pointed that besides evaporation, seepage in pond culture can be a considerable cause of water loss, depending on the type of soil. With time seepage through pond bottoms becomes less due to accumulated organic material. The water lost through seepage has also a higher Nitrogen and Phosphorus content than the water in the pond: up to 28% of the Nitrogen and 44% of the Phosphorus in the fish feed can be lost with the seepage water. Growing fish that consume 1 kg of feed also produce 560 g. of CO2, 40 g. of Nitrogen released as ammonium, and 100 to 250 g. of feces. The removal of these waste products and the supply of oxygen will make water exchange necessary, but aeration and recirculation of water can reduce the water demand from 4 – 8 m³/kg fish production in night-time aerated ponds to less than 0.5 m³/kg fish produced in intensive recirculation systems. After installation of recirculation systems (which was a requirement by the national government to reduce the environmental impact) trout farms in Denmark were able to reduce the water flow through their farms from 50 to 4 m³ per kg of fish produced, obtaining the same or higher total production on a significantly reduced farm area. Application of denitrification filters in recirculation systems can reduce the water demand even more, to less than 0.1 m³/kg of fish produced, as is shown by intensive indoor tilapia and eel farms in the Netherlands. Although recirculation systems have a low water use, the rationale for using these systems in Western Europe is year-round fish production in a temperate climate. This application could possibly be useful in Egypt for the production of tilapia fingerlings during winter.

Conclusions of the workshop are:
1. All stakeholder (consumers, farmers, fish farmers, government of Egypt, the environment and future generations) benefit when water resources and minerals are used as efficiently as possible.
2. The integrated system of water use “first fish, then crops” has the following advantages:
   - It uses water and nutrients more efficiently;
   - Reduces the risk of contamination of fish with agrochemicals;
   - Reduces unwanted pollution from fishponds going to the environment;
   - In general, from an agricultural point of view, it enhances the quality of irrigation water.
   - More organic matter in the water, which makes the use of filters almost a necessity when drip irrigation is applied.
   - The present capacity of canals and pumping stations will impose restrictions on its wide-scale implementation, requiring modifications of fish farm practices and better planning, management and coordination among farms of water intake and discharge.
   - Intensification of fish production (more kg fish/m³ of water) can lead to higher revenues for the producers.
   - Intensive fish farms in Egypt use at present 2.7 – 3.1 m³ water per kg of fish produced (with aeration, no recirculation).
   - Re-use of fishpond effluent (recirculation) can lead to further and significant decrease of water use in fish farming (presentations of Dr. Radwan and Mr. Kamstra).
   - Use of brackish and salt water for aquaculture is already taking place (presentation of Dr. Sherif
The integration of brackish/salt water fish farming with saltwater agriculture is at its infant stage of development in Egypt.

The objective of the workshop was to present the results of the study on water use at four Egyptian farms that apply integrated aquaculture – agriculture which was carried out by the World Fish Centre in 2010. In addition the results of other recent research undertaken in Egypt on integrated aquaculture – agriculture systems as well as experiences with such systems from outside Egypt were presented.
17. MARKET AND GLOBAL PRICES

Fitzsimmons (2008) focused in a paper presented at the 8th International Symposium on the fact that almost all tilapia is sold in domestic markets in Egypt. The paper suggested that Egypt, with its central location on the Mediterranean and extensive trade with the European Union and the States of the Arabian Peninsula, should be a major exporter of tilapia goods as well. The constraints to tilapia exports were listed as being: 1) Production of tilapia in sub-optimal water conditions, 2) Lack of Best Management Practices (BMPs) for production conditions, 3) Lack of sufficient Hazard Analysis at Critical Control Points (HACCP) and International Standards Organization (ISO) approved processing plants, 4) Lack of value added capabilities (freezing, breading, packaging, etc.), 5) Lack of by-product industries.

There are four main wholesale markets in Egypt: the Obour “in Cairo governorate”, October “in October governorate”, Tanta “in Gharbia governorate” and Suez in “Suez governorate”. They function as centers for distributing fish to retail markets, supermarkets, fish stores and local markets, in every town and village that does not have direct access to a fish landing centre (Fig. 47 and photos 35, 36, 37, 38, 39, 40).

![Figure 47: Possible market shares of the principle market segments for farmed fish in Egypt](image)

`Figure 47: Possible market shares of the principle market segments for farmed fish in Egypt`
Flow of farmed fish to different market segments

The fish stock market is to study the market movement and the harmonization process of supply and demand, not forgetting the pilot pricing may sometimes be obliged to control any speculation and manipulation in the market (Photo 41).

The infrastructure includes the exchange of fish - says the managing director of the stock exchange - three stages: the first was the establishment of 67 stores of commercial services, including restaurants, pharmacies and shops for the sale of yarn and oil cars and shops to sell ice at a cost of 3 million pounds, these stores had been put up an auction, then the second phase included the creation of 124 shops for the sale of fish, and rental shop two thousand pounds for a period of ten years, while the third phase will be on an area of 5 feddan and includes the establishment of 3 factories for snow and hard plastic and fish feed, has also been completed to connect the water line, particularly the stock market at a cost of half a million pounds and the power line at 900 thousand pounds, sewage line to 12 million pounds.

During the past few days there were addressing for the banks to establish branches out to take ownership by providing facilities of all kinds of loans and credit facilities to finance the projects of fish, especially for small-scale producers, to help them to compete with the top producers for the fishing industry and market. There
will be an ambulance unit to serve the international route and three gates will be constructed, the first to enter, and the second to come out, and the third for ice plants. It is predicted that the volume of daily trading in the wholesale fish within the stock market will be about 500 tons, and up revenue to 4 million Egyptian pounds per year.

Detailed costs and earnings data on fish farm production of tilapia and mullet in other countries against which Egyptian performance could be benchmarked, are not widely available. However, recent global and regional prices for tilapia from a number of sources are provided. These prices demonstrate the variability in prices not just between countries, but between markets within those countries. They also show that prices in Egypt as presented earlier in this report are generally low compared to other countries (table 12).

**Table 12: Global and regional tilapia prices, 2010-2011**

<table>
<thead>
<tr>
<th>Country</th>
<th>Prices</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>$4.00/kg</td>
<td>Live fish in traditional markets</td>
</tr>
<tr>
<td>Malaysia</td>
<td>$6.00/kg</td>
<td>Whole fish supermarket</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>$1.20-2.00/kg</td>
<td>Retail</td>
</tr>
<tr>
<td>Middle East</td>
<td>$2.10/kg cfr</td>
<td>Whole dressed fish retail</td>
</tr>
<tr>
<td>USA</td>
<td>$3.53/kg</td>
<td>Frozen fillet wholesale</td>
</tr>
<tr>
<td>USA</td>
<td>$7.00/kg</td>
<td>Fresh fillet wholesale</td>
</tr>
<tr>
<td>USA</td>
<td>$5.00/kg</td>
<td>Live whole fish wholesale</td>
</tr>
<tr>
<td>USA</td>
<td>$1.50/kg</td>
<td>Frozen whole fish wholesale</td>
</tr>
<tr>
<td>South Sudan</td>
<td>$2.70/kg</td>
<td>Retail whole</td>
</tr>
<tr>
<td>Kenya (Nairobi)</td>
<td>$3.00-5.00/kg</td>
<td>Retail whole</td>
</tr>
<tr>
<td>Kenya (Nairobi)</td>
<td>$8.30/kg</td>
<td>Fresh fillet, supermarket</td>
</tr>
<tr>
<td>Kenya (Nairobi)</td>
<td>$1.85-2.00/kg</td>
<td>Whole wholesale</td>
</tr>
<tr>
<td>Uganda</td>
<td>$1.96/kg</td>
<td>Wild tilapia retail</td>
</tr>
<tr>
<td>Egypt</td>
<td>$1.70</td>
<td>Tilapia farm gate price</td>
</tr>
<tr>
<td></td>
<td>$1.76</td>
<td>Tilapia wholesale price</td>
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<tr>
<td></td>
<td>$2.04</td>
<td>Tilapia whole retail price</td>
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<tr>
<td></td>
<td>$1.50-2.00/kg</td>
<td>Wild Nile tilapia retail (Mineya governorate)</td>
</tr>
<tr>
<td>Nigeria</td>
<td>$3.00/kg</td>
<td>African Catfish - Ex-farm price</td>
</tr>
<tr>
<td>Egypt</td>
<td>$1.31/kg</td>
<td>Catfish - Ex-farm price</td>
</tr>
</tbody>
</table>

18. VALUE CHAIN ANALYSIS

In a recent study, Macfadyen (2011) states that the farmed fish value-chain in Egypt is strongly based on the production of tilapia, with mullet a key second species, and with small quantities of carp and catfish also contributing to farm production. Some key features of the value-chain are that:

- There are virtually no exports of farmed fish, and so the value-chain is a short and simple one compared to aquaculture value-chains in some other countries;
- There is no processing at all of farmed fish i.e. all fish is sold in whole form, with no value-addition either through primary processing into fillets or into other secondary processed products (e.g. ready meals, etc.);
- Most fish are sold either fresh on ice (in summer months or if sales are made far from farms) or fresh with no ice (in winter months and/or if sales are made close to farms). There is a growing trend however for the sale of live tilapia, motivated by the fact that fish prices have fallen in real terms over the last ten years and higher prices can be achieved for live product;
- There is a very short time-period from harvest to final consumption by the consumer (due to the live/fresh nature of all sales), and very low rates (<1%) of post-harvest losses (which is in contrast to many wild fisheries value-chains in developing countries); and
- Direct employment creation throughout the value-chain is significant, at around 14 full-time equivalents for every 100 tonnes of fish produced and sold. This employment is fairly evenly divided between those over and under 30 years of age, and is mostly accounted for by men, although some female employment is created in the retail sub-sector. Considerable additional indirect employment creation results from sector activity through jobs created through the production of inputs used by the value-chain i.e. jobs in feed mills, hatcheries, ice plants, suppliers of vehicles, water pumps and generators, building contractors, and manufacturers of boxes used during transport.

Constructing costs and earnings models for each link in the value chain, allows for a comparison across the various sub-sectors, and for performance to be assessed both individually in each governorate and across all governorates. Some key findings from the data analysis made possible by the fieldwork completed during the study are:

- Fish farmers obtain a high percentage (72%) of the final consumer price, due to the lack of any exports, the short-supply chain, and the lack of value-addition in the value-chain;
- The average total production cost across all fish-farms is LE 7,769/MT. This represents the breakeven weighted sales price i.e. the average price of all fish sold by a farm must be more than LE 7,769/MT if the farm is to make a profit;
- Feed costs represent a very high percentage in all governorates of operational costs for the farming sub-sector (67% of operational costs);
- Operational costs represent a very high percentage of total costs for all sub-sectors in the value-chain i.e. fixed are relatively small;
- In the farming sub-sector operational profits are 29% of sales and net profits 22% of sales. Corresponding figures for the trader/wholesaler sub-sector are 4.1% and 3.9%, and for the retail sub-sector are 7.1% and 6.8%; and
- Operational profits generated throughout the value-chain are LE 4,460/MT of fish produced/sold, net profits are LE 3,736/MT, and value-added (net profits plus wage earnings) is LE 4,619MT, with the farming sub-sector contributing more than 60% of total profits/value-added for all of these indicators.
19. **AUTHORIZATION SYSTEM**

According to Law No 124/1983, to establish a fish farm a licence must be obtained from the Ministry of Agriculture, which is issued after obtaining authorization of the Ministry of Water Resources and Irrigation.

The license must indicate the quantity of water permitted for water use, its source, inlet size and the method of drainage, as well as the authorization obtained from the Ministry of Water Resources and Irrigation, including the conditions.

20. **ACCESS TO LAND AND WATER**

According to Law No 124/1983, only brackish and marine water, and infertile land that is not suitable for agriculture, can be used in aquaculture. Water supply should be restricted to water from lakes and drains, and the use of fresh (i.e. irrigation) water is prohibited, although hatcheries established by the government are exempted from this rule. By Decree, the Ministry of Agriculture may specify areas for fish farming.

Presidential Decree No 465/1983 describes the powers and duties of GAFRD, including the right to lease all lands within 200 m of shorelines for aquaculture and fisheries activity. In addition, Decision No. 70/1986 deals with the renting of land allocated by the GAFRD for the establishment of fish culture and hatcheries. A Committee of the Authority is responsible for defining areas suitable for fish farming and hatcheries, and for dividing them into economic units for leasing. Rental value should take into account the capacity of production, location, and availability of public utilities. Land is to be rented by public auction unless:
- Rental is to government bodies, public companies or legal persons.
- Projects are large, and have been proved economically feasible.
- Where no bids are received, or bids are below the rentable value.
- Where existing leases are in operation at the introduction of the decision.

The period of lease is to be five years, with 20 percent of the annual rent paid as deposit, and non-refundable in case of breach of conditions. The GAFRD may revoke the lease with two weeks written notice.

21. **EIA:**

Environmental Impact Assessment (EIA) is implemented in Egypt under the amendments have been codified in Directive 2011/92/EU of 13 December 2011.

Law No 4/1994 concerning the environment provides for the creation of the Egyptian Environment Affairs Agency (EEAA). The Act states that new establishments or projects as well as expansions or renovations of existing establishments must be subject to an EIA. The EIA should be submitted to the Competent Administrative Authority (CAA), under which jurisdiction the establishment or project falls. The CAA assesses the EIA and sends a copy to the EEAA for review. Subsequently, the CAA issues the license. The Act is implemented by Executive Regulation No 338/1995, which identifies the establishments and projects that must be subjected to an EIA based upon four basic standards, namely: the type of activity, location of the project, exploitation of natural resources and the type of energy used in the operation. To address the demands of processing EIAs and creating a uniform structure for the submitted EIAs, the EEAA has developed Guidelines for Egyptian
Environmental Impact Assessment, which describes in detail the procedures for the preparation of an EIA. The approach adopted in the Guidelines depends on the classification of projects into the following three categories reflecting increasing levels of EIA according to the severity of possible environmental impacts: they describe the screening method which is based on three lists of project types: white list projects with minor environmental impacts; gray list projects which may result in substantial environmental impacts, and black list projects for which complete EIA is mandatory due to the magnitude and nature of the potential impacts (METAP EIA, 2000).

The Guidelines include two screening forms, form A for white list projects and form B for grey list projects. For grey list projects the EEAA may require a scoped EIA which scope is defined by the EEAA on the basis of the information presented in form B. The Guidelines include a general outline of the content of a full EIA report, as well as sectoral guidelines that define the content of EIA reports for establishments that need full EIA.

Reportedly, fisheries projects belong to the grey list, which requires fish farmers to fill in form B. However, fish farms situated in ecologically sensitive areas such as protected areas, or in urban areas, may be considered black list projects and require a fully fledged EIA study.

**Water and wastewater**

Law No 48/1982 prohibits the discharge into the Nile River, irrigation canals, drains, lakes and groundwater without a license issued by the Ministry of Water Resources and Irrigation. However, Law No 48/1982 is only applicable to inland waters. Law No 4/1994 concerning the environment deals with seawater pollution from ships and prohibits the discharge of materials that cause pollution into coastal water and seawater from land based sources, unless a license has been issued by the EEAA.

Under both laws, licenses can be issued only for the discharge of effluents that meet government standards and each license should specify the allowed quantity and quality to be discharged. License holders should provide suitable and adequate units for waste treatment. Licenses can be revoked under certain conditions. If, for example, the pollution level of a licensed discharge increases and the facility fails to install appropriate treatment within a certain period, the license can be revoked. Law No 4/1994 may require an EIA to be carried out.

Law No 124/1983 generally prohibits disposing any industrial wastes, insecticides, and other poisonous and radioactive materials in the Egyptian waters.

### 22. FISHERIES AND AQUACULTURE POLICY

The General Authority for Fishery Resources Development (GAFRD) laid down, in 2005, a policy for the development of the fisheries and aquaculture sector in Egypt until 2017. The overall aim of the policy is to increase the return on fish resources through environmentally compatible systems; attain annual production of 1.5 million ton (an annual per capita of local fish production which amounts to 16.5kg) by 2017 so as to maintain per capita of fish production given the growing population; improve fish products from various sources to be compatible with international requirements; and support marine aquaculture. The policy has three major objectives:

1. Ensure use of natural fisheries to achieve sustainability, whilst exploring the possibility of using unexploited areas and types.
2. Maximize revenues from aquaculture projects, especially water resources. This could be achieved through incentivizing private and cooperative sectors and implementing research projects that seek to maximize return in this sector.

3. Reform institutional structures for fisheries resources and build capacity. The structure and mandate of GAFRD needs to be reviewed, particularly those related to control, regulation, enforcement of regulations, implementation of pilot and exploratory projects in the field of development, modernization and guidance.

One of the key issues in the policy is that it proposes that GAFRD ought to desist from activities related to production, use of water surfaces and aquaculture, which should be undertaken by the private and cooperative sectors. The role of GAFRD would be limited to setting environmental, health, economic and social standards. In other words, it should assume the role of regulator rather than producer (Goulding and Maggie Kamel, 2012) Arab Republic of Egypt, Strategic Framework for Economic and Social Development Plan until 2022).

To achieve the above mentioned objectives, the policy proposes undertaking the following measures:

1. Modernize fishing legislation and criminalize destructive fishing practices, fishing in shallow waters and in the Northern lakes to preserve the natural nurseries of young fish; creation of non fishing zones.

2. Carry out study on fish resources in the exclusive economic zones (EEZ), in collaboration with specialized scientific centers, with the support of available expertise to develop short and long term fisheries management plans.

3. Provide training courses to fishermen to emphasize the importance of fisheries data and information; and raise their awareness about fishing techniques and new technologies.

4. Identify suitable locations for marine fish cages – whether floating or immersed – seeking international expertise in this area whilst laying down environmental rules and conditions suitable for the capacity of the water bodies.

5. Survey areas and actual locations suitable for marine aquaculture along the Mediterranean Sea and Red Sea coasts and specify the type of activity that can be undertaken in each location.

6. Encourage private sector to plant mollusks enlisting the help of international and local expertise and investigate exporting opportunities.

7. Develop Lake Nasser and study fish resources in it.

8. Encourage establishment of marine hatcheries and identify suitable locations for their establishment.

9. Raise average productivity of existing aquaculture to 5 ton/feddan provided that cost of production remains economically viable.

10. Give more attention to the main types of fish (Nile tilapia) through genetic enhancement programs to improve productivity.

11. Promote investment in the fish feed while supporting industries with the aim of developing national supplies of inputs (whether feed, tools or equipment).

12. Promote aquaculture in fresh water and desert land on the condition that utilization of water resources remain sustainable.

13. Suggest alternative training programs to employ fishermen during fishing ban periods.

14. Amend rules of fish farms tenancy between GAFRD and investors to ensure stability and a rewarding economic returns; facilitate credit facilities from banks. The increase in rent should be within the limits of commercial activities.

15. Protect northern and internal lakes.
23. **SAFETY OF EGYPTIAN FARmed TILAPIA**

Posted by Kristina Rösel under Animal Products, CRP37, CRP4, Egypt. A recent analysis showed that the aquaculture value chain in Egypt is mainly based on the production of tilapia (Oreochromis niloticus) and mullet (Mugil cephalus and Liza ramada). The value chain was found to be short with no post-harvest processing (Macfadyen et al. 2011).

In October 2012, WorldFish facilitated a 2-week mission to Egypt for four scientists in the Safe Food, Fair Food (SFFF) project from West Africa and with expertise on fish safety who had been trained in participatory risk analysis photo (42). During the mission, tools were developed and tested to assess the safety of farmed tilapia. These drafts were later expanded and refined into a generic toolkit by the International Livestock Research Institute in collaboration with the Royal Veterinary College (RVC) and are currently applied in selected animal value chains: Egypt (fish), Ethiopia (small ruminants), Tanzania (dairy), Uganda and Vietnam (pigs).

Preliminary results from a very small (convenient) sample of tilapia collected during that initial study suggest that the levels of chemical hazards are rather small – which is of course good news for the industry! These positive findings will hopefully soon be confirmed by the results from a larger and representative sample which is currently being examined and complemented by microbiological analysis.

Top left: Auction of fresh fish at wholesale market in Kafr El Sheik (photo credits: Mahmoud Eitholt); Top right: Mission participants look at a map showing the distribution of fish farms in Northern Egypt (photo credits: Malcolm Dickson); Bottom: Improved strain of farmed tilapia (left) and grey mullet (right) (photo credits: Malcolm Dickson)

*Photo 42: 2-weeks mission to Egypt for four scientists in the Safe Food, Fair Food (SFFF).*
24. **CERTIFICATION**

Certification programs probably should be initiated at places where producers are already using good production methods. Production systems integrated with irrigation systems, do not cause pollution and should be prime candidates for trial certification.

25. **FISH MOVEMENT**

Act No 124/1983 prohibits the collection and removal from the sea, lakes or other water bodies of fish fry (i.e. young or newly hatched fishes) without a permit issued by GAFRD. In addition, it is not allowed to introduce non-indigenous species into the country, except with permission from GAFRD.

26. **FEED**

There is no information on specific provisions on the use of fish feed.

27. **AQUACULTURE INVESTMENT**

Law No 8/1997 on investment guarantees and incentives (as implemented by Decision No 2108/1997, as amended in 1998 and 2000) outlines the purposes of investment projects in Egypt, both domestic and foreign in origin. The Law is applicable to all establishments whose activities include – inter alia – fish production.

Decision No 2108/1997 specifies fish production into fishing activities and the development of fish breeding ponds. Establishments that wish to be eligible to the guarantees and incentives under the Law must apply to the General Authority for Investment and Free Zones (one-stop-shop regime). More information on investments in Egypt can be obtained at http://www.gafinet.org/ and http://www.theebcc.com/ipo/.

28. **INTERNATIONAL LEVEL**

Egypt, has a serious interest with the African countries in the exchange of experiences in order to achieve food security in the field of aquaculture, in which Egypt has recorded its success to a high standard and the development of models for this experiment and exchange of experiences.

The head of the General Authority for Fish Resources Development, indicated that there is a pilot study for a fishery project that projects the experience of Egypt in fish farming be applied in many African countries, so that this project becomes a factor that drive aquaculture production towards increased production.

This came during the signing of a cooperation protocol in the field of aquaculture and continental fisheries, between Egypt and the Republic of Congo, in the presence of Ambassador Rafael Malonga, Ambassador of the Republic of Congo. Ambassador Malonga his pleasure with the signing of this Protocol between the two countries, noting that there cooperation existed between the two countries since 1964 and the current protocol will be a joint cooperation for agriculture and fisheries, especially in development of fishcage culture, for the exchange of expertise to increase productivity, February 2012.

The second session of the Egyptian-Mauritanian joint in the field of fisheries in Cairo in May 2008, where it was stressed to continue to cooperate in the following areas; fishing and aquaculture financial, manufacturing and marketing of fish, sourcing a shipping line Freight, to benefit from the Egyptian experience in aquaculture,
encourage joint scientific research, personnel training and exchange of experiences, were also signed on 25/11/2008 for on the project to activate some of the terms of a protocol of bilateral cooperation in the field of maritime fishing aims at implementing some joint projects through the years 2009-2010.

Between 1996 and 2004 soft loans were provided to the aquaculture sector by the Multi Sector Support Programmed (MSSP), a development programme of the Ministry of Agriculture and Land Reclamation (MALR) which was funded by the European Commission (EC). The overall objective of MSSP was to increase income and job opportunities in the rural areas. The main target groups were the small and medium scale farmers (Naziri, 2011)

MSSP provided loans for investment in four distinct sectors: horticulture; poultry, aquaculture and irrigation & drainage development. With regard to aquaculture MSSP focused particularly on some specific type of activities Table (13):

- Intensification of existing production operations (funding of running costs, especially inputs including fry, feeds, and energy).
- Development of freshwater hatcheries to produce mono-sex tilapia fry (in order to reduce the shortage of supply).
- Development of marine hatcheries and nurseries (mainly for mullet, sea bass, sea bream and shrimps).
- Investment in feed mills and extrusion plants (in order to reduce the shortage of supply in terms of quality and quantity).
- Investment in improved marketing facilities (mainly ice production units, refrigerated storage and refrigerated or insulated vehicles).

<table>
<thead>
<tr>
<th>Table 13: Sector Allocations for MSSP Approved Loans</th>
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<td>Sector</td>
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<tr>
<td>Aquaculture</td>
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<td>Horticulture</td>
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<td>Irrigation &amp; Drainage</td>
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<td>Poultry</td>
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<tr>
<td>Total</td>
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Aquaculture Project grew out of an agreement between the Egyptian government and the United States Agency for International Development (USAID). On September 7, 1978, an agreement was signed between USAID and The Government of Egypt to participate in this project. A Presidential decree no 70 for 1979 was issued to confirm approval of the agreement. The Project initially began as the National Aquaculture Center, established to provide leadership in research, training and extension in applied aquaculture. Abbassa was chosen as the site for the national center because of its strategic location in region where many fish farms centralized. The construction began in 1981. The project was funded through a grant of $23.4 million from USAID with counterpart funding of L.E .7.7 million from Egyptian Government. CLAR joined the Agricultural Research Center on November 12, 1991 and is now firmly established as one of the most important national centers for aquaculture research in Egypt.
29. **Zoonosis and health hazards**

Clinostomum sp. the causative agent of “yellow grub disease” in tilapia may establish in laryngeotrachitis and give rise to a condition known as halzoun like disease in human.

Heterophyes heterophyes causes mild inflammatory reactions that may occur when they attach to the intestinal wall, giving rise to colic, excessive mucous production and diarrhea. More severe pathology may occasionally be due to the eggs, which may pass to the mesenteric lymphatics or heart musculature, where tissue reactions may occur.

Streptococcus iniae has attained a considerable importance in human medicine as it results in human infections especially during handling of diseased fish inducing cellulitis of the hand and fever. Moreover other patients showed serious infection causing diabetes and/or rheumatic heart disease (Weinstein et al., 1997) and the risk of disease was increased in immunocompromised workers, especially if they suffer cuts or puncture wounds (*Shoemaker and Klesius, 1997*).

Some species of aeromonas may cause human health hazards as: Septicaemia mainly in immunocompromised individuals; Cellulitis and wound infections; Diarrhea most commonly watery in consistency and sometimes cholera-like of short duration. Occur in all ages but mainly in children less than 3 years. Several reports associated Aeromonas species with travelers’ and chronic diarrhea. A number of food poisoning outbreaks have been reported.

Ataguba and Okomoda (2012): concluded that, integration of fish and poultry farming may clearly present new opportunities for the dissemination of HPAI H5N1 viruses through poultry feces either by direct feeding or by incorporation into feed for export which could provide opportunities for long distance spread of the virus, more so, wild infested bird on transit may transfer the virus by virtue of contact of the saliva with pond water while drinking from the pond or searching for food in a pond. Awareness of the health hazard of these should be more emphasized while research should be intensified on how best to use poultry manure without being exposed to the risk of avian influenza infection. FAO (2013) reported, mapping for influenza A (H5N1) virus transmission pathways and critical control points in Egypt.

Rappaport and Sarig (1978) reported that the addition of chicken manure to fish ponds results in reduction of the food conversion rate and Djajadiredja et al. (1980) reported that poultry manure is known to be the most powerful fertilizer for fish ponds. In Egypt, breeder and layer litter are preferred for fish farms because they are considered nutrient-rich due to the quantity of spilled feed they contain.

Movement of vehicles among different farms and locations without sanitary precautions at farm and collection point levels clearly present opportunities for the dissemination of avian influenza virus to poultry, fish farms and crop land (Engelen, 2011).

30. **Our concern about tilapia:**

Hormonal sex reversal, super male, tilapia shrimp integrated farm, nutrition for Omega-3 production, disease control and the big problem of death below 10 oC still the major Nile tilapia farming.

One feddan = 1.038 acres = 0.42 ha
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