On-farm feed management practices for Nile tilapia *(Oreochromis niloticus)* in Egypt

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ABSTRACT

Between February and May 2010 a survey was undertaken to evaluate on-farm feed management practices for Nile tilapia (*Oreochromis niloticus*) in Egypt. Data were obtained from 64 tilapia farmers and 6 aquafeed mills from the three major tilapia production governorates (Kafr El-Shaikh, Behaira and Sharkia), which produce over 80 percent of the farmed tilapia in Egypt. The results of the survey indicated that the production of farmed Nile tilapia increased from only 24 916 tonnes in 1990 (2.28 percent of total aquaculture production) to 386 186 tonnes (55.7 percent) in 2008. Tilapia culture in Egypt is primarily practiced in semi-intensive systems in brackishwater ponds. In 2008, over 80 percent of production (315 253 tonnes) was undertaken in semi-intensive systems. Nevertheless, tilapia polyculture systems, incorporating mullets and carps, remain a common practice in many areas; however, they are gradually being replaced with monoculture all-male Nile tilapia. About 75 percent of the surveyed tilapia farmers in these areas adopt mono-sex tilapia culture. Intensive Nile tilapia culture practices in earthen ponds, tanks and cages are slowly spreading in many areas of the country.

There are no standardized feeding and fertilization strategies, and the majority of the tilapia farmers do not apply the correct regimes. Poultry manure is the most important organic fertilizer used. It is estimated that about 6 to 7 percent of the poultry manure available in Egypt is used in aquaculture. In some areas, tilapia farmers no longer use organic fertilizers but fertilize their ponds with chemical fertilizers. This is only undertaken prior to the stocking of fish; both urea and superphosphate are generally used. Fertilization rates are typically between 20 to 40 kg superphosphate per hectare (average ~30 kg/ha), in addition to 10 to 25 kg of urea/ha (average 20 kg/ha).

Currently, the commercial aquafeed manufacturing industry in Egypt is expanding rapidly. The number of aquafeed mills increased from only 5 in 1999, to 31 in 2009. Current aquafeed production is approximately 420 000 tonnes/year, about 280 000 tonnes (65 percent) of which is used for tilapia. Sinking pellets, with a crude protein (CP) content of 25 percent are predominant. However, extruded aquafeed technology was introduced in Egypt in the mid-1990s; tilapia farmers prefer them as they are better digested and converted to body mass. The feed conversion ratios (FCR) attained when using pelleted Nile tilapia feeds range

from 1.5:1 to 2.5:1, while those for extruded feeds range from 1.1:1 to 2:1. Hand feeding, twice per day (early morning and late afternoon) is the most common feeding practice. However, the use of locally-made demand feeders is expanding, especially among medium to large-scale farmers. It is estimated that the use of processed feeds contributed about 48 percent of total tilapia production; the rest is attributed to natural food attained by pond fertilization. Farm-made feeds are rarely used by Egyptian tilapia farmers; none of those surveyed used them.

Fifty to seventy-five percent of the ingredients used in aquafeeds in Egypt are imported. As a result, prices have been increasing substantially; in consequence the prices of both pelleted and extruded tilapia feeds have increased 2 to 2.5 times over the past decade. The major constraints faced by tilapia farmers and the aquafeed manufacturing industry include the escalating price of processed feeds and feed ingredients, high customs tariffs on feed ingredients, the poor handling and storage of feed ingredients and finished feeds, access to finance for the small scale producers, and the unavailability of larval and fingerling feeds. Recommendations to address these issues are provided in this report.

1. INTRODUCTION

Tilapia are freshwater cichlid fish that, while native to Africa, were introduced into many tropical, subtropical and temperate regions of the world during the second half of the 20th century (Pillay, 1990; El-Sayed, 2006). They have many attributes that make them excellent candidates for aquaculture, including fast growth rates, a high tolerance to a wide range of environmental conditions, resistance to stress and disease, the ability to reproduce in captivity, a short generation time, the ability to feed at a low trophic level, and the acceptance of artificial feeds immediately after yolk-sac absorption. It is believed that tilapia culture originated about 4 000 years ago (Balarin and Hatton, 1979). During the past two decades, global tilapia culture has increased significantly; currently about 100 countries rear tilapia. As a result, global production of farmed tilapia has increased from 383 654 tonnes in 1990 (2.28 percent of total aquaculture production) to 2 505 452 tonnes in 2007 (2.93 percent). The average annual production growth rate during this period approached 13 percent and tilapia now ranks as second only in importance to carps (Fitzsimmons, 2008). This author also predicted that tilapia would become the most important aquaculture crop in this century, continuing to be a preferred source of income and protein for impoverished rural communities in developing countries.

Semi-intensive tilapia culture has been adopted in various parts of the world, either in monoculture or polyculture systems. Recently semi-intensive tilapia culture with other herbivorous/omnivorous fish such, as carps (common carp *Cyprinus carpio*; silver carp *Hypophthalmichthys molitrix* and grass carp *Ctenopharyngodon idella*) and mullets (flathead grey mullet, *Mugil cephalus* and thinlip grey mullet, *Liza ramada*) has seen significant expansion, particularly among small-scale farmers in Asia, Africa and Latin America. In recent years there has been a rapid, global industrialization of tilapia production. This has lead to a gradual shift in tilapia culture from traditional, low-input, semi-intensive systems to more intensive farming practices, with an increasing dependence on formulated feeds. In many regions this has created a disparity between seed supplies and demand, and a concomitant increase in demand for formulated feed. Currently, the major challenge facing the tilapia culture industry is the production of sufficient amounts of quality seed. The formulation of appropriate feeds in order to optimize reproductive outputs, seed production and growth performance, is also a key factor for promoting tilapia culture. Commercial tilapia culture is currently restricted to about 10 species. However, the Nile tilapia (particularly mono-sex male populations) is by far the most important species; between 1970 and 2008 the production of farmed Nile tilapia represented more than 80 percent of the total global production of farmed tilapia.

Tilapia culture has traditionally been practiced in Egypt for thousands of years. An

Egyptian tomb frieze dated at about 2500 B.C. depicts a tilapia harvest, and suggests that fish may have been cultured for human consumption (Chimits, 1957; Bardach, Ryther and McLarney, 1972). However, the first modern commercial tilapia farm was built in 1957 at Manzala (near Mansoura, Dakahlia governorate) and operated by the Egyptian government. This farm had a total area of 440 ha of earthen ponds, and was used for growing Nile tilapia, common carp and flathead grey mullet in polyculture systems (Eisawy and El-Bolok, 1976).

Nile tilapia (Figure 1) is currently the only cultured tilapia species. A tilapia hybrid (Florida red tilapia) was introduced into Egypt in the 1980s but rearing trials almost ceased in response to consumer dislike of the hybrid and preference for Nile tilapia. It was only during the 1990s that Nile tilapia was recognised as an important aquaculture species. This recognition was associated with the expansion of semi-intensive culture systems in earthen ponds. The expansion was driven by private fish farmers and the development of privately-owned hatcheries and feed mills.

FIGURE 1
Harvested Nile tilapia

COURTESY: FAO/A.-F.M. EL-SAYED.

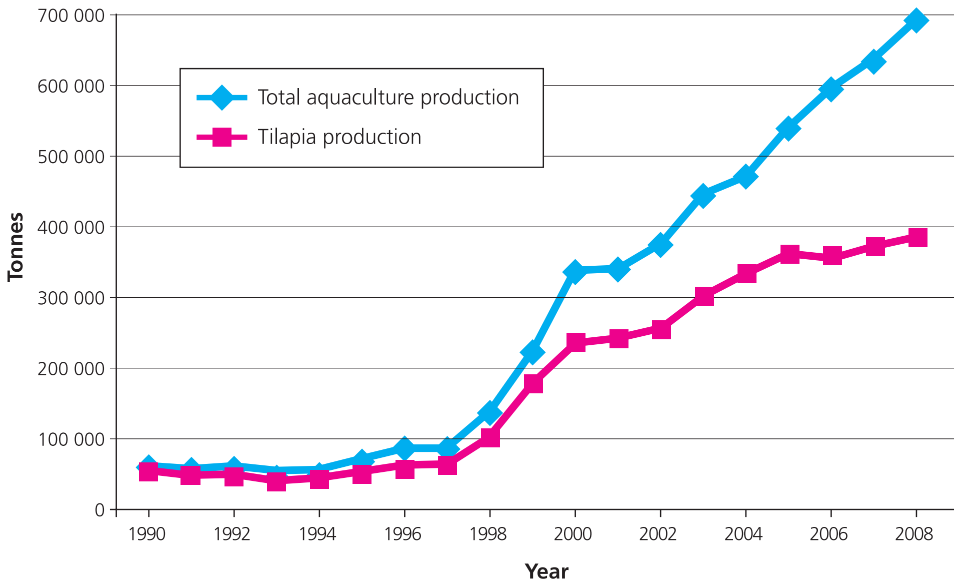
As a result of the continuous development of tilapia aquaculture in Egypt, the production of farmed tilapia increased from only 24 916 tonnes in 1990 (2.28 percent of total aquaculture production) to 386 186 tonnes in 2008 (55.7 percent), as shown in Table 1 and Figure 2). As a result, Egypt is now the second largest tilapia producer in the world, after China.

TABLE 1
Aquaculture production (tonnes) by species and production system in Egypt in 2008

Category	Production system				Total	Percent of total production
	FW ponds/tanks[1]	BW ponds[2]	Cages	Rice fields		
Nile tilapia *(Oreochromis niloticus)*	1 602	363 126	10 458	11 000	386 186	55.66
Mullets *(Mugil cephalus; Liza ramada)*		150 663	58 650		209 313	30.17
Carps *(Cyprinus carpio, Hypophthalmichthys molitrix; Ctenopharyngodon idella)*		61 805		11 400	73 205	10.55
North African catfish *(Clarias gariepinus)*	120	8 324		5 500	13 944	2.00
Gilthead seabream *(Sparus aurata)*	50	4 430			4 480	0.65
European seabass *(Dicentrarchus labrax)*	50	4 333			4 383	0.62
Meagre *(Argyrosomus regius)*		2 031			2 031	0.29
Others[3]		273			273	0.06
Total	**1 822**	**594 985**	**69 108**	**27 900**	**693 815**	**100**

[1]Freshwater intensive pond; [2]brackishwater semi-intensive ponds; [3]including shrimp *(Penaeus japonicus, P. semisulcatus)*, bayad *(Bagrus bagrus, B. bayad)* and Nile perch *(Lates niloticus)*.
Source: GAFRD (2009).

FIGURE 2
Aquaculture production in Egypt, 1990–2008



Source: GAFRD (2009).

All-male Nile tilapia currently represents a substantial proportion of farmed tilapia production. All-male, mono-sex tilapia populations are produced using an oral administration of 17α-methyltestosterone (MT). The hormone is generally incorporated into larval feeds at a dose of 30 to 60 mg/kg and administered to undifferentiated, swim-up larvae (5–8 days after hatch; 1 to 2 days after yolk sac absorption) for 25 to 30 days. The process produces about 85 to 95 percent males. Tilapia broodstock and larvae are generally fed with diets containing relatively high protein levels (30 to 35 percent), compared to the 25 percent protein diets that are commonly used during the rest of the production cycle.

Almost all-small scale farmers buy their tilapia seeds (both mono-sex and mixed-sex) at 2 to 5 g from commercial hatcheries. Hatcheries are located in most of the tilapia production areas. In addition, most large-scale tilapia farmers in Kafr El-Shaikh, Behaira and Sharkia produce both mono-sex and mixed-sex tilapia for their own farms, and also for selling to other farmers in the region. The peak of production and selling of hatchery-produced tilapia fingerlings is generally at the beginning of farming season (May and June). Usually, farms only produce one crop per annum, with the fish being harvested in November and December, or overwintered through December till March/April.

The development of tilapia culture depends, amongst other factors, on the availability and accessibility of inputs, including feeds and fertilizer resources. Information relating the source, nature, quantity, quality, price, seasonality, production, import, export and distribution of feeds and fertilizers among the various users and stakeholders is required to maintain a successful tilapia culture sector. Currently there is a paucity of information related to the availability of feed and fertilizer resources that are used for tilapia culture in Egypt. In addition, the available information suggests that there are no specific standards for feeding and fertilization regimes. Farmers in different geographical regions adopt different feeding and fertilization strategies; these may also vary between farmers within the same region. Therefore, in-depth analyses of existing aquafeed and fertilizer management practices, and the promotion of better management practices, are an essential prerequisite to the development of sustainable, cost-effective tilapia culture in Egypt.

This study reviews the current status and trends in fertilizer and feed use in Egypt. Information on the availability, accessibility, and utilization of these resources for different farming systems has been collected and synthesized. This information can be used to assist fish farmers (especially tilapia farmers) and aquafeed producers to maximize their use of the available feed inputs. It will also enable the government authorities and other concerned stakeholders/organizations/associations to make appropriate decisions to promote aquaculture development and sustainability.

The objectives of the study were to:

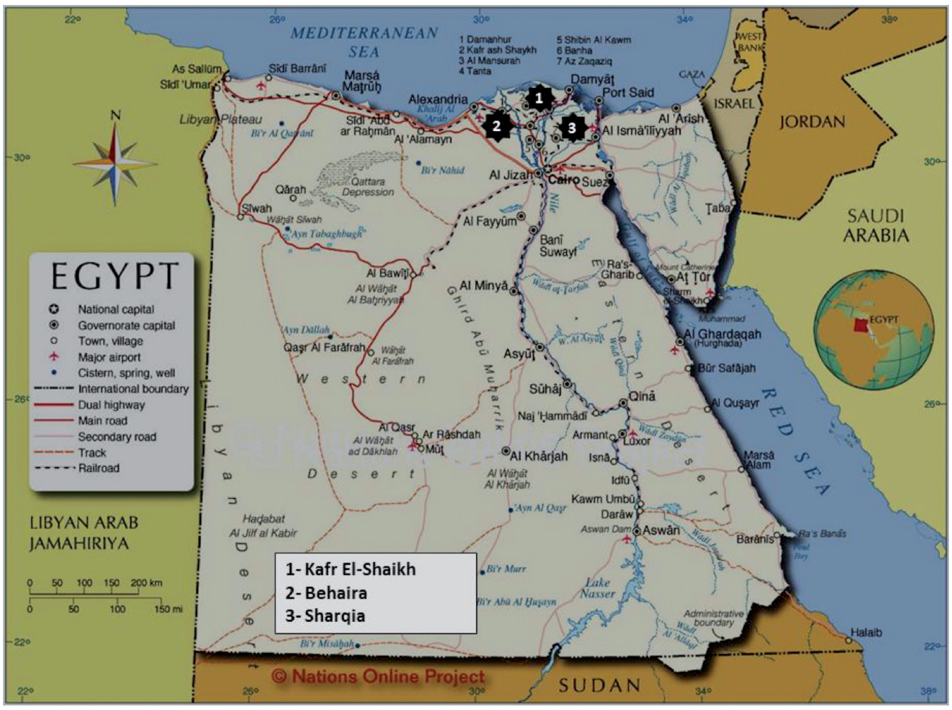
- Evaluate the use of processed feeds, farm-made feeds and fertilizers in the major areas where tilapia culture is practiced.
- Conduct a cost-benefit analysis of these resources to compare production costs.
- Identify the further potential for tilapia feed production in Egypt.
- Identify the main constraints to tilapia feed management practices, and suggest appropriate solutions to these constraints.

2. METHODS

A structured questionnaire was developed and distributed during February and May 2010 to a randomly selected group of small and large-scale tilapia farmers; these comprised a representative sample from the major production governorates, namely Kafr El-Shaikh, Behaira and Sharkia (Figure 3). Tilapia production from these governorates accounts for over 80 percent of total farmed tilapia in Egypt. The majority of tilapia farms here are small-scale, semi-intensive pond farms. Tilapia cage farms are restricted exclusively to Rashid (Rosetta) Branch of the Nile in Behaira and Kafr El-Shaikh governorates. Based on the type of farming practices and the number of tilapia farms in each of the three governorates, farms were randomly selected to provide a representative sample of the different types of culture facility. Sampling was also designed so that the surveys covered the widest possible geographical area.

Initially, the questionnaires were distributed through field visits and via phone calls to the farmers. However, the due to problems associated with using these methods,

FIGURE 3
Map of Egypt showing the three study governorates



Source: www.nationsonline.org

technicians and aquaculture consultants were employed to assist in the deployment of the survey. A similar questionnaire to that used for the farmers was developed for the aquafeed industry and distributed among 6 aquafeed mills (4 private and 2 public). The surveys were collected through field visits or via phone and/or E-mail. A total of 64 farmers responded to the questionnaire (Table 2) and six aquafeed mills responded (4 private and 2 public).

TABLE 2
Sample allocation in the three main tilapia culture governorates in Egypt

Governorate	Culture facilities surveyed				Total	Areas surveyed
	Semi-intensive ponds	Intensive ponds	Intensive tanks	Intensive cages		
Kafr El-Shaikh	23	1	1	3	28	Hamool, Baltim, Borullus and Desouk
Behaira	14	2	2	8	26	Barsiq, Maadia, Edco, Rashid (Rosetta) and West Nubaria
Sharkia	9	1			10	Abbasa, Abou Hammad, Salhia
Total	**46**	**4**	**3**	**11**	**64**	

Source: Field survey (2010).

The information obtained from the surveys was collated, tabulated and sorted into different categories, *viz.*:

- Farming system (semi-intensive, intensive tank, intensive pond and intensive cage culture).
- Cultured species (mixed-sex tilapia, mono-sex tilapia and polyculture).
- Ownership (private and governmental).

All data were coded and entered into a Microsoft Excel spreadsheet for statistical analysis, primarily comprising simple descriptive statistics.

3. RESULTS AND DISCUSSION

Nile tilapia are reared in several types of systems in Egypt, including semi-intensive pond culture, intensive cage culture, intensive pond culture and intensive tank culture.

3.1 Semi-intensive pond culture

Semi-intensive tilapia culture is primarily practiced in brackishwater environments, particularly around the northern delta lagoons. Semi-intensive fish culture in earthen ponds is by far the most important farming system and accounted for 84 percent of aquaculture production in Egypt in 2008. Semi-intensive production in earthen ponds increased from 191 000 tonnes in 1999 to 315 253 tonnes in 2008; currently it accounts for 45 percent of total aquaculture production (693 815 tonnes) and 82 percent of total tilapia production (386 186 tonnes) (Table 1). Pond culture is primarily practiced mainly by private sector. In 2008, the private sector produced 685 268 tonnes of tilapia, equating to about 99 percent of total pond production. In contrast, the governmental sector produced only 8 547 tonnes (~1 percent). The major producing governorates for pond production were Kafr ElShaikh, Sharkia, and Behaira. In 2008, these governorates accounted for about 80 percent of pond tilapia production. Moreover, Kafr El-Shaikh alone produced 173 371 tonnes, representing 43.8 percent of total tilapia production (GAFRD, 2009).

3.1.1 Pond preparation

Survey results suggest that semi-intensive tilapia culture in earthen ponds is the dominant farming activity in the study areas (>90 percent). Tilapia ponds, particularly in and around the northern Delta lakes, are typically constructed by enclosing parts of the shallow coastal areas and dividing them into fish ponds. Ponds are also constructed in depressed irrigated or saline lands. Pond depths range from 70 to 150 cm, with an average of ~1 metre. Minimal attention is paid to pond preparation. Most tilapia ponds are drained for harvesting and remain dry for long periods (3 to 4 months). Most tilapia farmers harvest their crops in early winter, as the fish cannot tolerate the severe drop in water temperature in winter. However, some polyculture farmers extend the production cycle throughout the year (or more). Drained ponds remain dry from December/January to April. The majority of semi intensive farmers do not apply specific pond preparation strategies. Drained and harvested ponds are simply left to dry until the mud surface cracks. One reason why pond preparation and maintenance is low is that most of small-scale farmers do not have official rental or ownership contracts. Instead, they informally rent their ponds from large-scale farmers or land owners at much higher rental rates than the governmental rates. Therefore, those farmers generally refuse to add inputs to the ponds as they have unsecured tenure. Occasional removal of the mud layer and the tilling of the pond soil before pond filling takes place in governmental tilapia farms. Very few private pond farmers till their ponds.

3.1.2 Cultured species

Typically, Nile tilapia (*Oreochromis niloticus*), mullets (flathead grey mullet *Mugil cephalus* and thinlip grey mullet *Liza ramada*) and carps (mainly common carp; grass carp and silver carp are occasionally used) are reared semi-intensively in earthen pond polyculture systems. In 2008, the combined production of these three groups from semi-intensive systems accounted for 82 percent of total aquaculture production (45.4 percent, 30.2 percent and 6.5 percent, respectively). The fish are stocked at 5 000 to 15 000 fish/feddan (12 000 to 40 000 fish/ha). Stocking ratios vary considerably. However, tilapia accounts for 60 to 80 percent of the stocked fish. The stocking sizes of tilapia, mullets and common carp are 2 to 10 g, 20 to 50 g and 5 to 20 g, respectively. Mullets are generally nursed separately at high densities for about 6 to 8 months, until they reach the required size. The cultured species are stocked in April/May in order to reach market size at about the same time, namely after 8–10 months.

However, in many areas, particularly in Behaira governorate (Edko and Rashid), polyculture systems are becoming less common, and are being replaced by monoculture systems producing all-male Nile tilapia. This is mainly due to the low acceptance of cultured carp in these areas, insufficient mullet seed supplies, the higher growth rates associated with all-male tilapia, and market acceptance. About 75 percent of surveyed tilapia farmers in these areas farm mono-sex tilapia. Monoculture of mixed-sex tilapia is still a common practice in many areas in Kafr El-Shaikh and Sharkia governorates. The production of semi-intensive systems varies from 3.5 to 10 tonnes/ha/production cycle (6 to 10 months).

3.1.3 Pond fertilization – organic

In semi-intensive tilapia culture systems, almost all small-scale farmers depend on poultry manure for fertilization. Fertilization rates range from 2 to 4 tonnes/ha. Generally, prior to filling, the farmers spread the dry fertilizer on the pond bottom (Figure 4). Other farmers pile the dry manure on the pond dikes and spray it with water for few days, before washing it into the ponds. In comparison to applying dry manure, this process enhances decomposition processes and reduces the time needed to maximize primary production. The nutrient composition of the major manures in Egypt is provided in Table 3.

FIGURE 4

Piling organic fertilizers on pond bottoms before filling with water

TABLE 3

Nutrient composition (%) of selected manures

Manure	Dry matter	Nitrogen	Phosphorus	Potassium	Organic matter	N:P ratio	C:N ratio
Chicken	68.00	3.40	1.75	1.67	39.00	1.90	8.00
Duck	74.00	2.00	1.30	1.20	41.00	2.00	9.00
Buffalo	72.00	1.90	0.70	1.20	36.00	3.50	22.00
Cow	76.00	2.10	0.80	1.10	38.00	3.30	20.00
Goat	71.00	0.80	0.10	0.10	32.00	4.10	17.00
Sheep	73.00	1.00	0.20	0.20	34.00	3.80	18.00

N:P = nitrogen: phosphorus; C:N = carbon: nitrogen.
Source: El-Sayed (1999).

In some cases, fresh manure is used directly for pond fertilization, particularly in Sharkia and Behaira governorates, where livestock production is commonplace. Fresh manure may be preferred to dry manure as it disintegrates in water into colloidal particles that are easily accessible to bacteria, and the nutrients are readily incorporated into food web.

The majority of farmers are not familiar with fertilization protocols (rates, quantities, frequencies, etc.). Poor fertilization practices may lead to deterioration in water quality and fish mortality. A number of farmers in Kafr El-Shaikh and Behaira Governorates reported massive mortality of farmed tilapia due to the excessive application of organic fertilizers (El-Sayed, 2006, 2007). In some areas of Behaira governorate (Edko, Rashid), tilapia farmers no longer use organic fertilizers. Instead, prior to stocking, they fertilize their ponds with inorganic fertilizers and apply supplemental feeding based on commercial pellets for the entire production cycle.

3.1.4 Pond fertilization – inorganic

The use of inorganic fertilizers in pond fertilization is limited. About 10 percent of the surveyed semi-intensive farmers apply inorganic fertilizers alone, while 26 percent used mixtures of both inorganic and organic fertilizers. The majority apply inorganic fertilizers only once at the beginning of the production cycle. A small proportion of farmers apply inorganic fertilizers (generally at 15-day intervals) when the productivity of the ponds decreases. Both urea and superphosphate are used. The ratio and amounts applied vary considerably between farmers and farming areas. Normally application rates are between 20 to 40 kg superphosphate per ha (average: ~30 kg/ha), and 10 to 25 kg of urea (~20 kg/ha).

There are no accurate records on the volumes of inorganic fertilizers currently used. However, it is estimated that between 600 to 1 000 tonnes of urea and 900 to 1 500 tonnes of superphosphate (a total of 1 500 to 2 500 tonnes) were used in 2008 for pond fertilization. At these application rates competition with field crops for inorganic fertilizer is unlikely to occur, at least in the short term. In the foreseeable future, organic fertilizers are expected to remain the major source of fertilizers that are applied.

3.1.5 Supplemental feed and feeding practices

The majority of monoculture and polyculture farmers only fertilize their ponds prior to fish stocking; seldom afterwards. Many farmers start feeding tilapia with commercial feed (25 percent protein) as early as 3 days after stocking. This is probably not the best husbandry policy as well-fertilized ponds provide sufficient natural food for cultured fish at this time, and supplemental feeding can be delayed by up to 2 months. Abdelghany, Ayyat and Ahmad (2002) found that when Nile tilapia ponds (reared with common carp and silver carp) were fertilized bi-weekly with 750 kg chicken litter, 100 kg triple superphosphate and 20 kg urea per ha, supplemental feeding could be delayed for up to 6 weeks without any reduction in fish yields; this resulted in a significant reduction in feed costs. Green, El Nagdy and Hebicha (2002) reported that first feeding could be delayed to up to 60 days. Similarly, Diana, Lin and Yi (1996) found that Nile tilapia can be grown up to 100 to 150 g with fertilizers alone, while feeding the fish before they reach this size is wasteful (Table 4).

TABLE 4

Feed and fertilization strategies suggested for optimum yield of tilapia in semi-intensive systems

Cultured tilapia			Fertilization regime	Feeding	Culture period (days)	Yield (tonnes/ha)	Remarks	Reference
Species	Size at stocking (g)	Density (no./ha)						
Nile tilapia male	1–3	20 000	Chicken manure, 1 000 kg/ha/week for 60 days 54.4 kg urea plus 92.4 kg super phosphate/ha/week	30% CP* diet, 3% BW**/day, feeding starts at day 60	145	7.40	African catfish (59 g) were used for controlling over-population of tilapia	Green, El Nagdy and Hebicha (2002)
				No feeding		3.20		
Nile tilapia Silver carp Common carp	13.8 1.9 10.7	30 000	750 kg chicken litter/ha, bi-weekly application, plus 100 TSP and 20 kg urea/ha	25% CP diet, 3% BW/day, 6 weeks after stocking.	133	4.75	Feeding at 6-week delay was comparable to no delay, and better than at 13-week delay.	Abdelghany, Ayyat and Ahmad (2002)
Nile tilapia (85%) + catfish (15%) + 300 silver carp	0.3 132 100	30 000–50 000	Chicken litter (550 kg/ha/week) or monophosphate (72.5 kg/ha/week) and urea (45 kg/ha/week)	25% CP floating pellets, twice a day, to satiation, 60 days after stocking	190	4.9–8.6	Best growth at 3 fish/m^3, regardless of type of fertilizers	El Naggar, Ibrahim and Abou Zead (2008)

*CP = crude protein; **BW = body weight.

At present, there is a gradual shift among small- and medium-scale tilapia farmers to move from relying on pond fertilization to external feeding. About 70 percent of the surveyed pond farmers use commercial pellets throughout the entire production cycle, particularly in Behaira Governorate (Edko, Rashid and Maadia) and Kafr El-Shaikh governorate (Khashaa, Hamool and Baltim).

The majority of tilapia farmers (65 percent of those surveyed) use sinking pellets, while the remaining 35 percent use extruded (floating) pellets. Generally, 30 to 35 percent CP diets are used for fingerlings; 25 percent CP feeds are used later in the production cycle. However, many farmers use 25 percent CP throughout the whole production cycle.

Hand feeding, twice a day (at 07.00 to 08.00 and 16.00 to 17.00 hours), is the most common feeding practice among small-scale tilapia farmers. Most do not feed the fish at a calculated percent of their body weight per day; they simply provide given quantities of feed based on their previous experience, and it is likely that they are underfeeding their fish. This assertion is reflected by the reported productivity of the ponds, which is generally lower than that reported in other countries (El-Sayed, 2006).

The use of locally-made, cheap demand feeders (Figure 5) is spreading, especially among the medium- to relatively large-scale farmers. These feeders comprise a cone-shaped plastic, metallic or glass fibre hopper, with a narrow opening at the bottom. A steel free-swinging activator rod is inserted from the middle of the opening and positioned below the hopper to about 10 to 15 cm under the water surface. When the fish touch or activate the rod, feed pellets are allowed to slowly drop on the water surface. The application of these feeders enables the fish to eat only when hungry. Normally, between 8 to 12 feeders per ha are deployed at fixed distances along the pond sides.

FIGURE 5
Demand feeders commonly used for feeding tilapia in semi-intensive and intensive systems

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The feed conversion ratio (FCR) of pelleted feeds for Nile tilapia raised in semi-intensive systems varies considerably, and is dependent on the fish stocking size, densities, and fertilization regimes. The FCR attained using pelleted feed for fingerlings ranges from 1.7:1 to 2.1:1, while that for floating feeds range from 1.2:1 to 1.6:1. For the fattening stages of the production cycle, the FCR of pelleted and extruded feeds range from 1.3:1 to 1.8:1 and 1:1 to 1.4:1, respectively. It should be emphasized that these values may be misleading, as natural feeds are an inherent component of total food consumption; thus, making FCR determinations is problematic.

3.1.6 Production cycle and harvest

As a result of inappropriate feed and fertilization regimes in tilapia ponds, fish yields are relatively low compared with well-fertilized, well-fed ponds in other countries. The yields range between 3 to 6 tonnes/ha/production cycle (about 6 to 8 months). There are a few exceptions, where production in monoculture can reach 8 to 10 tonnes/ha/cycle; however, in these cases the production cycle is generally longer (9 to 11 months).

A longitudinal ditch, about 50 cm deeper than the main pond, is generally dug at one side for fish wintering and harvesting. When the pond is drained, the fish are forced to move into the ditch. Fish harvesters pull the fish to one end of the ditch using nets, where they can be removed using scoop nets (Figure 6). The production cycle, stocking sizes, feeding schedules and the common use of fertilizers in polyculture systems is summarized in Table 5.

FIGURE 6
Harvesting Nile tilapia in semi-intensive ponds in Kafr El-Shaikh, Egypt

Source: www.nationsonline.org

TABLE 5

Production cycle, feeding schedules and common use for fertilizers for Nile tilapia in polyculture systems in Egypt

Month	Size (g)			Feeding schedules			Type of fertiliser	
	Nile tilapia	Mullet (*M. cephalus*)	Common carp	Feed type	Feeding frequency per day	Feeding rate (% of body weight)	Organic (poultry manure)	Inorganic superphosphate/ urea
1	2–10	20–50	5–20	Floating/ sinking	2–3 times	4–6	x	x
2	5–20	30–70	10–30	Floating/ sinking	2–3 times	3–4	x	x
3	15–40	50–100	20–50	Floating/ sinking	2–3 times	3–4	x	x
4	30–80	80–130	40–100	Floating/ sinking	2 times/demand feeder	2–3	x	x
5	60–130	100–150	80–150	Floating/ sinking	2 times/demand feeder	2–3/satiation	-	-
6	100–170	130–180	120–200	Floating/ sinking	2 times/demand feeder	2–3% BW/satiation	-	-
7	140–220	160–220	150–250	Floating/ sinking	2 times/demand feeder	2/satiation	-	-
8	200–250 [Harvest]	200–250 [Harvest]	180–300 [Harvest]	Floating/ sinking	2 times/demand feeder	2/satiation	-	-
9	250–300 [Harvest]	230–280 [Harvest]	230–350 [Harvest]	Floating/ sinking	2 times/demand feeder	2/satiation	-	-
10	>300 [Harvest]	250 – >300 [Harvest]	280 – >400 [Harvest]	Floating/ sinking	2 times/demand feeder	2/satiation	-	-

Note: Fertilizer not used from beginning of month five.

Source: Field survey (2010); Abdelghany, Ayyat and Ahmad (2002); El-Sayed (2006); A. Kasem, personal communication, 2012; M. Soliman, personal communication, 2012; W. El-Hawwary, personal communication, 2011.

3.2 Intensive cage culture

3.2.1 Cage location and construction

Over the past decade, tilapia cage culture has been spreading rapidly throughout the country, most notably in the Domiat (Damietta) and Rashid branches of the Nile River. As a result, cage production has increased from 12 900 tonnes in 1999 to 69 108 tonnes in 2008, and currently accounts for 18 percent of total tilapia production. Cage culture is practiced exclusively by the private sector.

Rectangular and square cages measuring 32 m^3 (4 x 4 x 2 m) to 600 m^3 (10 x 10 x 6 m) are commonly used. The cages are made of wooden frames and synthetic netting. Empty, closed plastic barrels (50 litre capacity) are fixed underneath the frames to serve as floats (8 to 12 floats per 600 m^3 cage). The cages are used in the Nile (Rosetta branch) in groups or arrays (Figure 7). Professional divers are occasionally employed to monitor the cages, remove the fouling and repair any damage that may have occurred to the nets.

FIGURE 7
Culture of Nile tilapia in floating cages in Rashid branch of the Nile River

3.2.2 Stocking density and feeding

Tilapia fingerlings (3 to 10 g) are stocked at 80 to 100 fish/m^3. The fish are initially fed with commercial feeds (35 to 40 percent CP, reduced to 25 to 30 percent during the latter part of the production cycle). The majority of cage farmers use extruded pellets (2–3 mm in size). If large sized overwintered fish (30 to 50 g) are stocked, they are generally fed with 5 mm pellets during the last 2 to 3 months of the production cycle. The use of floating pellets saves about 25 percent of the feed that would otherwise be lost from the cage – if pelleted feeds (sinking pellets) are used. The feeds are fed either manually (2 to 3 times per day) or from demand feeders.

Feed conversion ratios (FCR) attained using pelleted feeds in cage culture range from 1.5:1 to 2:1 for fingerlings to 1.3:1 to 1.7:1 for the grow-out period. In contrast, the FCR attained using extruded feeds range from 1.2:1 to 1.5:1 and 1:1 to 1.2:1 for fingerling and grow-out stages, respectively.

3.2.3 Production cycle and yield

Some cage farmers use the 'young-of-the year' (5 to 10 g) for stocking, while others stock over-wintered fish. After 9 to 13 months, farmed 'young-of-the year' tilapia reach about 300 to 500 g, with a total production ranging from 25 to 40 kg/m^3 (about 15 to 25 tonnes per 600 m^3 cage). Some cage farmers stock the fish at larger sizes (over-wintered, 40 to 100 g) and, in turn, reduce the production cycle to about 6–8 months.

3.2.4 Environmental impacts of cage culture

The wide expansion of tilapia cage culture in the Nile River has increased public awareness to aquaculture and created a debate among governmental authorities, academics and environmental protection bodies about the environmental impacts of these farming operations. In the past, the government removed the cages from the Damietta (Domiat) branch of the Nile, claiming that fish faeces and feed wastes from the cages were polluting the river and causing severe ecological and health problems. This action divided public opinion. Those in favour of tilapia cage culture suspect that the cages pollute the Nile but claim that this culture system is practiced globally. They suggest that removing the cages is not the solution, and that resolution could be sought by: improving management systems, such as limiting the number of cages per square kilometre; the use of high-quality feeds; optimised feeding strategies; the appropriate selection of cage sites; and the farming of other fish species such as silver carp that, as filter feeders, would reduce organic loads. Continuous governmental monitoring and inspection could certainly minimize the effects of the cages. In general, researchers, academics and farmers are in favour of this point of view. In contrast, the environmental protection authority and governorate administration claim that the cage culture activities are resulting in deteriorating water quality, and very likely constitute a health hazard. Therefore, they believe that removing the cages is the only solution to the problem. Unfortunately, removing the cages has been catastrophic for the farmers. Currently, tilapia cage culture is restricted to the Rashid branch of the Nile River.

3.3 Intensive pond culture

Intensive tilapia culture in earthen ponds is slowly spreading to many areas in Egypt, particularly in Behaira. This system is also gradually expanding in many newly reclaimed desert areas, where the culture water is subsequently used for land crop irrigation.

3.3.1 Pond preparation

In many respects pond preparation and management in intensive culture is similar to that adopted in semi-intensive systems. However the following differences apply:

- Only monoculture (mainly mono-sex) is practiced; polyculture is not applied.
- Ponds are aerated using air compressors or paddle wheels (see section 3.4.2). The number of air compressors and paddle wheels depends on the stocking density, culture stage and the levels of water replacement.
- Ponds are not fertilized, and the fish depend exclusively on formulated feeds.
- Despite the predominance of earthen ponds, the ponds walls in some areas (Nubaria and Behaira) are built with bricks and coated with cement. These ponds are generally rectangular or square in shape, with areas ranging from 200 m^2 to 4 000 m^2, and depths of 1 to 1.5 m.

3.3.2 Stocking densities and feeding

Tilapia are stocked at about 20 000 to 40 000 fish/feddan (50 000 to 100 000 fish/ha) and fed commercial aquafeeds (25 to 35 percent CP). The majority of tilapia farmers (70 percent of the surveyed sample) use extruded pellets, while the rest (30 percent) use pelleted feed. Generally, 30 to 35 percent CP diets are used during the fingerling stages of production; these levels are reduced to 25 percent CP during grow-out. However, many farmers use 25 percent CP during the whole production cycle. While hand feeding twice per day is practiced (at 07.00 to 08.00 and 16.00 to 17.00 hours), the use of demand feeders is increasing; currently, about 60 percent of the intensive pond farmers use demand feeders. Between 10 to 14 feeders per ha are distributed at fixed distances along the sides of the ponds.

The feed conversion ratios (FCR) attained using pelleted feeds ranges between 1.3:1 and 1.9:1 for fingerlings, and between 1.2:1 and 1.5:1 for the grow-out production stage. In contrast, the FCR attained using extruded feeds range between 1:1 and 1.4:1 for fingerlings and between 1:1 and 1.2:1 for the grow-out stage.

3.3.3 Production cycle and yield

Farmers stock the 'young-of-the year' (2 to 5 g) in the ponds between May and June, and the fish grow to between 150 and 200 g over the next 5 to 7 months. Some farmers stock over-wintered tilapia (>30 g average weight) which grow to about 300 g to >400 g in 6 to 9 months. The total production at harvest ranges between 15 and 20 tonnes/ha, depending on the stocking density and the culture period. The methods used for harvesting tilapia in intensive pond systems are similar to those applied to semi-intensive pond culture.

3.4 Intensive tank culture

3.4.1 Tank construction and preparation

Intensive tank culture of tilapia in Egypt is growing, especially in the arid and semi-arid areas where freshwater or brackish water is limited. Tanks are generally rectangular and of smaller size to earthen ponds, and constructed mostly of concrete. Intensive culture in concrete green house units is gaining popularity in some areas in Behaira and Kafr El-Shaikh (Figure 8).

The size and shape of tilapia culture tanks are variable, and depend on the culture objectives. Fry and nursery tanks are generally small (<2 to 12 m^3), while production tanks typically are much larger. In a tilapia farm at Al-Nubaria, Behaira, an intensive tilapia farmer uses 600 m^3 concrete production tanks (20 x 30 x 1 m) with muddy bottoms. Irrigation and underground water are pumped directly into the ponds and tank effluents are used to irrigate agricultural crops.

3.4.2 Stocking density and feeding

About 80 percent of tilapia farmers using tanks in the study areas raise all-male Nile tilapia. Fish are stocked at densities that range between 25 and 100/m^3, depending on the initial stocking size. Tanks are also aerated with air compressors (½-1 horse power, depending on tank size and stocking density), paddle wheels (Figure 9), or water sprayed over the tank surface. Tank water is also partially replaced with fresh water when the water quality deteriorates. Unfortunately, information pertaining to aeration timing and

FIGURE 8
Tank culture of tilapia in Salhia, Sharkia Governorate, Egypt

COURTESY OF FAO/A.-F.-M. EL-SAYED.

FIGURE 9
Intensive tilapia pond in Barsiq fish farm, Behaira, Egypt being aerated with paddle wheels

COURTESY OF A.A. BALHASHER.

duration, water pumping, and costs, is limited; it is therefore difficult to generalize, since individual farmers adopt different procedures and practices based on their own experience.

The fish are generally fed with commercial extruded feeds (35 percent CP at the beginning, reduced to 25 percent CP during the fattening stages). A very small number of farmers use sinking pellets (25 to 30 percent CP). As the tanks are smaller than ponds, hand feeding is generally used. Feeding is typically 2 to 3 times per day (07.00 to 08.00, 12.00 to 13.00 and 17.00 to 18.00 hours). None of the surveyed farmers use demand feeders.

3.4.3 Production cycle and yield

Similar to the cage culture production systems, some tilapia farmers stock the 'young-of-the year' (2 to 5 g) in the tanks between May and June. The fish grow to about 200 g over a 5 to 7 month period. Other farmers stock over-wintered tilapia (30 to 60 g) which grow to between 300 g and >500 g over a 6 to 9 month period. The total production of tank-cultured tilapia at harvest ranges between 10 to 30 kg/m^3, depending on the stocking densities and culture periods. The tilapia are harvested by draining the water from the tanks, mainly by gravity. Generally, the tanks have a slight slope towards the draining points to facilitate drainage. Fish are harvested using scoop nets.

3.5 Cost-benefit analyses

The cost and benefits accruing to tilapia farms vary considerably and are dependent on the culture system adopted, the availability and costs of inputs, and the geographical region. For example, the cost of labour varies between regions.

The average costs and benefit-cost ratios (BCR) associated with tilapia culture in semi-intensive and intensive farming systems are summarized in Table 6. The lowest net revenues and BCR are obtained using semi-intensive systems. This is attributed to the fact that these systems are primarily used by small-scale farmers who do not have regular access to funding and production inputs. As a result, total costs, revenue and BCR are generally low; however, the practice is still very profitable to those farmers. In contrast, intensive tilapia culture is practiced by farmers who have much better access to funds and production inputs, and can thus operate systems with much higher operational capital and investment. Therefore, the net revenues and BCR in intensive tilapia culture are much higher. The total costs are much higher in tank culture than in cage and pond culture. Nevertheless, the BCR attributed to cage production is the highest, followed by pond and tank culture respectively.

TABLE 6

Cost-benefit analysis and average production costs and returns for tilapia culture in Egypt (US$/ha/production cycle) in 2009

Costs and returns	Semi-intensive system	Intensive systems		
		Ponds	600 m³ cages	Tanks (0.4 ha)
Variable costs				
Seeds	110	273	262	545
Feeds	3 636	10 000	13 630	16 364
Fertilizers	272	-	-	-
Labour (family and hired)	727	727	364	727
Miscellaneous costs	800	1 200	500	1 700
Total variable costs (TVC)	5 545	12 200	14 756	19 336
Fixed costs				
Depreciation	-	-	300	1 000
Land use cost	1 680	1 680	-	1 680
Total fixed costs (TFC)	1 680	1 680	300	2 680
Total costs (TC = TVC + TFC)	7 225	13 880	15 056	22 016
Total gross revenue (GR)	9 600	24 000	29 000	32 000
Net return (NR = GR – TC)	2 375	10 120	13 944	9 984
Benefit-cost ratio (BCR = GR/TC)	1.33	1.73	1.93	1.45

3.6 Characteristics of feed production

3.6.1 On-farm tilapia feed manufacturing

The use of farm-made feeds is extremely limited; none of the surveyed farmers reported them. However, some farmers in remote, rural areas, who produce the fish primarily for family subsistence, make their own tilapia feeds. These farmers generally depend on local feed ingredients, including agricultural by-products (wheat bran, corn bran, rice bran) and animal by-products (blood meal, offal, poultry by-product, etc.). El-Sayed (2007) reviewed the production processes used in farm-made feed production. Ingredients are sorted to remove spoiled or rotten parts and hard objects that may damage the manufacturing equipment. The feedstuffs are milled and mixed according to a formulation, water is added, and the compounded ingredients are cooked or steamed, or extruded without cooking. Moist strands are extruded using an electric meat mincer. The strands are sun dried, broken up and stored. In some cases, farmers do not extrude the diets; instead they feed the moist paste to the fish in the form of moist feed balls. Some small-scale farmers feed the dry feed mixture either by filling jute bags and suspending these in the water column or by broadcasting them over the water surface.

3.6.2 Commercial aquafeed industry in Egypt

The rapid expansion of aquaculture and in particular tilapia farming over the past two decades has been accompanied by an increasing demand for commercially manufactured aquafeeds. The gradual shift from extensive and semi-intensive tilapia culture to more intensive, feed-dependent systems has further increased the demand for commercial feeds. As a result, the aquafeed industry has witnessed a sharp increase in production capacity over the past few years. The number of aquafeed manufacturing mills has increased from only 5 mills producing about 20 000 tonnes per year in 1999 (El-Sayed, 1999), to 31 mills in 2009 (11 belong to the public sector and 20 owned by the private sector; Table 7), with a current production capacity of 420 000 tonnes/year (Mohamed F. Osman, GAFRD, personal communication, 2010). These manufacturing plants produce both pelleted and extruded pellets for various marine and freshwater-cultured species (Table 8).

One of the most serious issues facing the aquafeed industry in Egypt is the poor handling and storage of the ingredients and the finished feeds. Stores in many feed mills lack the basic standards necessary for the storage and handling of materials to ensure feed freshness and minimize the exposure of the ingredients to contamination due to birds, rodents, insects and other environmental factors. Ingredients are often stored outdoors, on the ground, without any shading or protection (Figure 10). They are exposed to direct sunlight, heat, moisture, and the prevailing weather conditions. These poor storage conditions will certainly lead to the damaged ingredients and poor feed quality. Many farmers also store feed ingredients and purchased sacked feed on their pond dikes, often leaving them open to the prevailing weather conditions for several weeks – during which time the feed quality will almost certainly deteriorate.

In contrast, many private feed mills have excellent handling, storage and transportation facilities, and comply with the Code of Practice for Good Animal Feeding (FAO, 1998). However, the feed prices from these mills are generally higher than from the government-run feed mills.

FIGURE 10
An example of poor feed ingredient storage

Courtesy of FAO/A.-F.M. El-Sayed.

TABLE 7
Number of aquafeed mills and total fish feed production in Egypt in 1999 and 2009

Feed mills	1999	2009
Governmental/Public sector	5	11
Private	-	20
Total feed production (tonnes)	20 000	420 000

Source: El-Sayed (1999); K. El-Sharkawi, personal communication, 2010; M.F. Osman, GAFRD, personal communication, 2009.

TABLE 8
Commercially available complete aquafeeds in Egypt

Commercial product	Company	Examples of prices (US$/tonne)
Extruded and pelleted feeds for tilapia, carp, mullets and marine fish	Zoocontrol	500–650 (based on protein contents and type of feeds)
Pelleted pellets for tilapia, carp, and mullets	Barsiq feed mill (GAFRD)	360–450 (sinking pellets)
Pelleted pellets for tilapia, carps, mullets and seabream and seabass	Manzalla feed mill (GAFRD)	360–450 (sinking pellets)
Floating (extruded) tilapia feeds (1–5 mm) (25–40% CP), sinking tilapia feed (2–5 mm), marine fish feeds, aquarium fish feeds	JOE Trade	520 (25% CP; floating) 565 (30% CP; floating)

Source: Field survey (2010); personal contacts with the manufacturers.

3.6.3 Tilapia feed industry

Approximately 280 000 tonnes (65 percent) of the aquafeeds produced in Egypt are used for tilapia farming. Tilapia feeds are produced primarily in the form of conventional pelleted (sinking) pellets. Pellet sizes range between 2 and 5 mm, and the feed is mostly used in semiintensive culture systems – monoculture and polyculture systems with mullets and carps. A significant proportion of pelleted feeds is used in intensive, monoculture production systems.

Extruded (expanded, or floating) aquafeed technology was introduced into Egypt in the mid-1990s. Since 2001, a number of commercial, private feed manufacturers have added production lines for extruded feed production to complement their traditional production lines. The market demand for extruded feed is increasing, despite the significantly higher prices. Tilapia farmers prefer this type of feed because it is better digested, converted and assimilated by the fish (El-Sayed, 2007). Indeed, approximately 40 percent of surveyed tilapia farmers use extruded feeds. Feed conversion ratios (FCR) for pelleted Nile tilapia feeds range from 1.5:1 to 2.5:1, while the FCR associated with extruded feeds range from 1.1:1 to 2:1, depending on fish size and culture system (Figure 11). The formulation and proximal composition of typical 25 percent CP extruded and pelleted, and 35 percent CP pelleted feeds are presented in Table 9.

TABLE 9

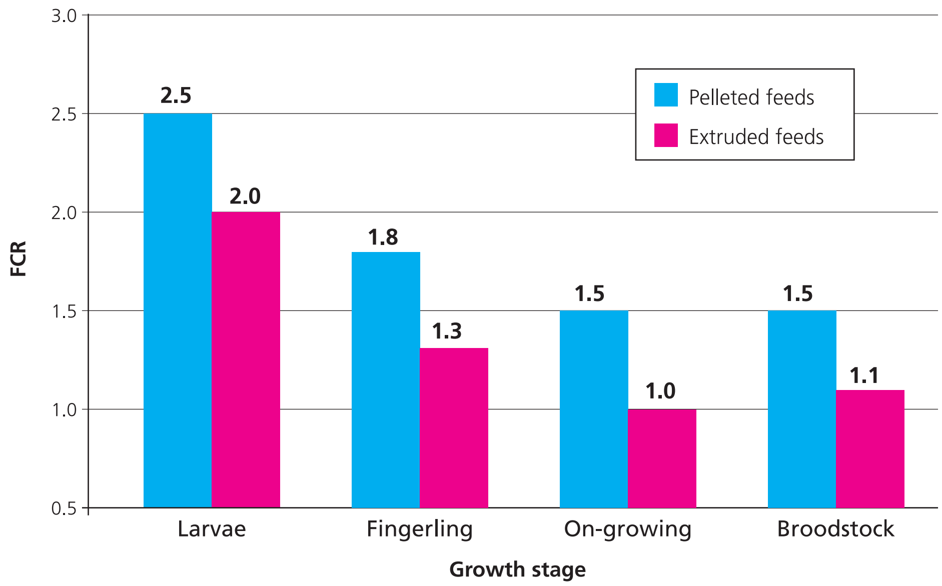
Formulation and proximate composition of commercial tilapia diets in Egypt

Feed type	25% CP diet		35% CP diet
	Pelleted (GAFRD; government mill)	Extruded (private sector)	Pelleted (GAFRD; government mill)
Ingredients (%)			
Soybean meal (44% CP)	37.5	19.0	40.0
Fishmeal (sardine, 60% CP)	6.0	9.0	22.0
Corn gluten	-	5.6	
Yellow corn	22.5	30.0	12.0
Wheat bran	-	24.0	-
Rice bran	23.0	11.0	19.1
Oil	3.0	1.0	3.0
Calcium carbonate	4.7	-	3.075
Binder	2.5	-	-
Table salt	0.5	-	0.5
Vitamin mixture	0.3	0.4**	0.3
Antioxidant	0.025	-	0.025
Proximate composition (% dry matter basis)			
Crude protein	25.0	25.0	35.0
Crude lipid*	8.8	7.5	8.4
Crude fibre*	5.7	5.4	6.3
Ash*	4.3	3.9	3.9
NFE*	56.2	58.2	46.4

Notes: *calculated by the author, based on the chemical composition of the ingredients; **vitamin and mineral pre-mix.
Source: GAFRD (General Authority for Fisheries Resources Development, Egypt).

The average FCR values presented in Figure 11 that are attributed to the different growth stages of Nile tilapia fed pelleted and extruded feeds were based on the values provided by the farmers, as well as published papers and reports. It is clear that the FCR of larval and fingerling stages are higher than those of grow-out and broodstock fish. This is primarily attributed to the fact that aquafeed manufacturers do not produce specialist larval and fingerling feeds (<1 mm). Instead, most of the farmers crush the feeds that are formulated for grow-out (2–3 mm) into pieces before feeding them to the fry and fingerlings. This practice leads to feed waste, resulting in higher FCR (lower feed utilization efficiency) in these early growth stages.

FIGURE 11
Average feed conversion ratios (FCR) of Nile tilapia fed commercial diets



Sources: Field survey (2010); El-Sayed (2004, 2006, 2007); Osman & Sadek (2004).

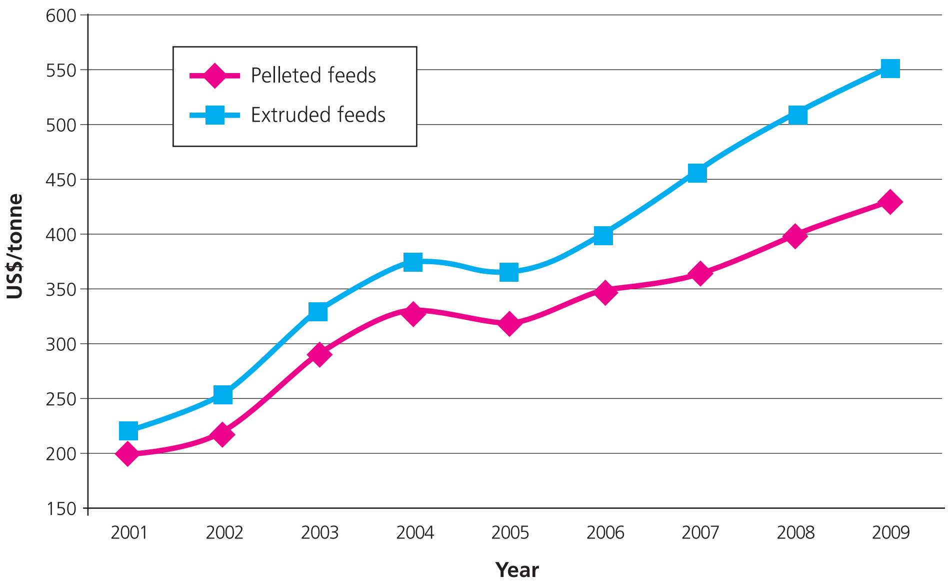
Commercially produced tilapia feeds are usually packed in 25 to 50 kg woven polypropylene bags (Figure 12). The bags are closed either manually with a string or mechanically heatsealed. Feeds are generally stored in shaded well aerated stores. However, some factories (especially government mills) lack appropriate storage facilities for their ingredients and finished feeds.

The prices for pelleted tilapia feeds in Egypt has doubled over the past decade, increasing from ~US$200/tonne (25 percent CP) in 2001 to US$400–450/tonne in 2009 (Figure 13). Similarly, the price of extruded feeds has increased 2.5-fold, from US$220/tonne in 2001 to about US$550/tonne and US$650/tonne (25 and 32 percent CP, respectively) in 2009. The increasing prices of both pelleted and extruded tilapia feeds have primarily been caused to increases in the prices of feed ingredients, especially those that are imported, such as fishmeal, soybean meal, corn, wheat bran and oils, as detailed in Section 3.7.2. In addition, increase in prices for extruded feeds is related to the high investment costs associated with the installation and operation of the specialist extrusion machinery.

FIGURE 12
Tilapia feed (25% CP) packed in 25 and 50 kg polypropylene bags

COURTESY OF FAO/A.-F.M. EL-SAYED.

FIGURE 13
Price of extruded and pelleted tilapia feeds (25% CP) between 2001 and 2009



Sources: Field survey (2010); El-Sayed (2007); K. El-Sharkawi, JOE Trade, personal communication, 2010.

3.7 Major feed ingredients

3.7.1 Locally produced ingredients

The estimated quantities of major feed ingredients that are currently used for the animal feed and aquafeed industries in Egypt are presented in Table 10. Most of these, especially the energy sources, are used for (terrestrial) animal feed production. Since 2004, the production of some oil seeds (linseed, cottonseed and soybean) has been decreasing.

TABLE 10

Production of major feed ingredients (thousand tonnes) in Egypt between 2004 and 2008

Item	International feed number (IFN)	2004	2005	2006	2007	2008
Cereals						
Barley	4-00-549	163	163	154	178	149
Maize	4-02-935	6 352	6 125	6 755	6 877	6 544
Rice	4-03-943	6 352	6 125	6 755	6 877	7 253
Rye	4-04-047	30	40	60	44	44
Sorghum	4-04-444	864	853	887	844	844
Wheat	5-05-211	7 178	8 141	8 274	7 379	7 977
Oilseeds						
Groundnuts, with shell	-	191	200	184	218	209
Linseed	-	30	28	10	12	12
Cottonseed	5-01-619	446	335	335	335	335
Sesame seed	5-04-220	29	37	42	42	37
Soybean	5-04-597	43	51	23	26	29
Sunflower	5-09-340	12	34	38	29	21
Oils						
Cottonseed oil	4-20-836	51	59	49	48	38
Linseed oil	4-14-502	10	14	9	4	12
Soybean oil	4-07-983	46	100	96	150	220
Sunflower oil	4-20-833	8	9	8	8	7

Source: FAO (2010).

3.7.2 Imported feed ingredients

Between 50 and 75 percent of feed ingredients that are used in aquafeed production in Egypt are imported. As a result, their prices have been increasing substantially over the past few years (Table 11). For example, between 2003 and 2007, the quantities of the major imported feed ingredients increased from 7 696 000 tonnes to 13 028 000 tonnes, equating to a 69 percent increase in imports. Similarly, the increase in the unit prices paid ranged between 7 and 78 percent. Thus, for the aquafeed industry to remain competitive, the Egyptian feed manufacturers need to source ingredients on the international markets at competitive prices.

TABLE 11

Imported quantities and prices of feed ingredients in 2003 and 2007

Ingredient	International feed number (IFN)	2003		2007		Increase in price (%)
		Thousand tonnes	US$/tonne	Thousand tonnes	US$/tonne	
Wheat	4-05-268	4 057	149	5 911	265	78
Maize	4-02-935	4 053	130	4 474	210	62
Soybean seed	5-04-597	332	268	1 136	376	40
Soybean cake	5-04-612	826	238	1 010	291	22
Sunflower oil	4-20-833	123	570	151	741	30
Gluten feed and meal	5-28-242	54	299	81	472	58
Soybean oil	4-07-983	107	530	96	728	37
Meat meal	5-09-323	137	325	87	350	7
Total		**9 796**		**13 028**		

Source: FAO (2010).

The estimated volume and value of major feed ingredients that are currently used by the aquafeed manufacturing industry for tilapia feed production is presented in Table 12. About 70 percent of these ingredients are imported, most notably the protein sources. As a result, the prices of aquafeeds are relatively high compared to other animal feeds (El-Sayed, 2007).

TABLE 12

Estimated quantities and values of the major feed ingredients used in total aquafeed and tilapia feed production in Egypt in 2008

Ingredient	International feed number (IFN)	Origin	Total aquafeeds		Tilapia feeds	
			Quantity (tonne)	Value (thousand US$)	Quantity (tonne)	Value (thousand US$)
Fishmeal	5-02-000	Imported	20 000	48 000	13 000	31 200
Meat meal	5-00-385	Imported	10 000	3 410	6 000	2 217
Soybean meal	5-04-612	Imported	100 000	27 645	64 750	17 969
Yellow corn	4-02-935	Imported	160 000	29 400	106 000	19 110
Rice bran	4-03-928	Local	40 000	75 000	26 000	48 750
Wheat bran	4-05-190	Local	80 000	60 000	52 000	39 000
Corn gluten meal	5-28-242	Imported	15 000	6 405	9 750	4 163
Soybean oil	4-07-983	Local	250	182	163	118
Vitamin and mineral premix		Local	150	600	95	390
Total			**375 400**	**247 232**	**278 758**	**162 917**

Source: Calculated by the author, based on the percentage of each ingredient in the feeds.

3.7.3 The contribution of pelleted feeds to tilapia production

Egypt currently produces about 420 000 tonnes of aquafeeds per annum, the majority of which is in the form of sinking pellets (25 percent CP). Approximately 280 000 tonnes of this feed (67 percent) is used in tilapia production. The average current feed conversion ratio (FCR) for tilapia using these feeds is in the region of 1.5:1; thus the amount of tilapia feed would probably produce about 187 000 tonnes of tilapia. In 2008, this level of production would represent 48 percent of the total production of farmed tilapia (386 186 tonnes). However, this figure is dependent on an estimated FCR, and thus may be higher or lower than the real value. Notably, it is difficult to determine accurate FCR when both natural food (produced through fertilization) and supplemental feeds are used in the same production cycle. The remaining tilapia production can be attributed to pond fertilization and natural feeds.

Evidently natural feeds, produced through pond fertilization, still play a key role as a nutritional input in tilapia aquaculture in Egypt. Dependence on pond fertilization is anticipated to continue, at least in the short term. This is simply due to the fact that it is easier and more convenient for small-scale Egyptian pond farmers to adopt semi-intensive culture systems.

In contrast, intensive tilapia culture requires high capital investment, high operational costs, and professional management. It would be very difficult for small-scale farmers to afford these costs. However, the shortage of freshwater and increasing competition for water resources from other sectors, such as agriculture and urbanization, suggests that there may be a gradual shift from the traditional semi-intensive to more intensive production systems. The limitation of potential aquaculture sites will also impose pressure on the industry to shift towards intensification. If this happens, the aquaculture sector will probably become dominated by large-scale producers who have access to the funding and level of technological inputs necessary.

4. PROBLEMS AND CONSTRAINTS OF TILAPIA FEEDS AND FEEDING

The following problems and constraints were reported by the surveyed farmers:

- Feed prices: all surveyed farmers complained about the high prices of both pelleted and extruded feeds.
- Variations in feed quality: approximately 40 percent of the farmers reported that they sometimes purchase poor quality feeds as they cannot differentiate between good and bad feeds.
- The increase in the prices of feed ingredients, particularly imported ingredients such as fishmeal, soybean, corn, oils and additives has led to parallel increases in feed prices.
- The unavailability of small sized pellets (<1 mm diameter) for larval and fingerling stages; most of the aquafeed mills in Egypt do not currently have the production technology to produce these.
- The high custom tariffs and taxes on imported ingredients and manufacturing equipment have contributed to rising feed costs.
- There are concerns that increasing competition for raw materials between the aquafeed and the animal feed industries may influence their price.
- One of the most serious problems facing the tilapia feed industry in Egypt is the poor handling and storage facilities for ingredients and finished feeds.
- Small-scale tilapia farmers lack access to finance, which makes them vulnerable to exploitation by the suppliers of the feeds and fertilizers. Many farmers purchase their feed during the production cycle but payment is delayed until after the fish are harvested and sold. As a result, they are generally supplied at higher prices.
- There is a lack of extension services to advise tilapia farmers on pond fertilization, feed formulation, manufacture and feeding practices.
- Small-scale, semi-intensive tilapia farmers are generally unaware of the appropriate fertilization strategies and the techniques that should be adopted to optimise pond productivity.
- There is limited applied research on tilapia nutrition, feeding and fertilization strategies.

5. RECOMMENDATIONS

It is clear from the foregoing discussion that extensive efforts should be made to improve feed and fertilization management practices. The following recommendations have been suggested by tilapia farmers, aquafeed manufacturers and researchers, and are designed to solve these issues:

- A thorough survey of the available conventional and unconventional feed resources in the country should be undertaken. An evaluation to establish their availability, accessibility, price and nutritional value for cultured fish should be conducted. The chemical composition of these sources should be identified.
- Consideration should be given to optimizing feed and fertilization strategies in semi-intensive culture systems. Pond preparation, fertilization rates and intervals, soil and water analyses, and the timing for initiating artificial feed supplementation are prime issues that need to be addressed.
- Reducing, or at least stabilizing, the prices of both feed ingredients and finished feeds, through reducing customs tariffs on feed ingredients and other production inputs, monitoring the profit margins of feed producers, followed by governmental intervention when necessary.
- Consideration should be given to the identification of novel dietary sources that can partially or totally replace standard protein and energy sources in fish feeds.
- Improving the quality of aquafeeds through improved handling, transportation, storage, processing and the removal of anti-nutritional factors (if present). The continuous monitoring of feed producers, suppliers and ingredients importers

by governmental authorities is necessary to assure that they comply with the international quality control standards, such as Hazard Analysis and Critical Control Points (HACCP) and the Code of Practice for Good Animal Feeding (FAO, 1998).

- Research efforts should focus on feedstuffs that have low digestibility and high fibre contents, such as sugar cane bagasse, reeds and water hyacinths, which are available in large amounts throughout the country. The quality of these potential ingredients can be improved by processing, such as heating, silaging and composting. In addition to their use as feed ingredients, they can be composted and used as fertilizers in fish ponds.
- The government should support fish farmers to access the necessary loans at appropriate lending rates to develop their businesses.
- There should be routine government inspections and monitoring of both feed ingredients used in aquafeed manufacturing and commercial aquafeed mills. This should be designed to ensure that that production procedures, packaging, handling, transportation and storage comply with the quality control standards issued by the government. Inspections should include, but should not necessarily be restricted to:
    - The analysis of feed ingredients for freshness, cleanliness and exposure to contamination due to birds, rodents, insects and environmental stressors such as heat, sun, rain, etc.
    - Finished feed distributed in the market or on-farm should be sampled and analyzed for protein, lipids, fibre and moisture contents and compared with the levels described on the labels. The presence of hazardous substances/additives, such as fungi, medicinal substances, hormones, pesticides, etc. should be checked. Appropriate methods should be adopted to eliminate such hazards.
    - Routine inspections on the cleanliness of feed manufacturing premises and equipment.
- Legislation and regulations should be issued by the government to guarantee the quality and safety of aquafeeds. These should define the responsibilities and designate authority with respect to the activities required, establish basic procedures for enforcement, and provide standards, guidelines and recommendations for the industrial manufacturing of aquafeeds. Legislation and regulations concerning the manufacture, handling, storage and use of aquafeeds should be coherent and complementary parts of the overall national feed/food legislation. The government should also undertake periodic reviews of the food/feed legislation to ensure its coherency, and to reduce/eliminate any overlapping, redundant and conflicting jurisdictions.

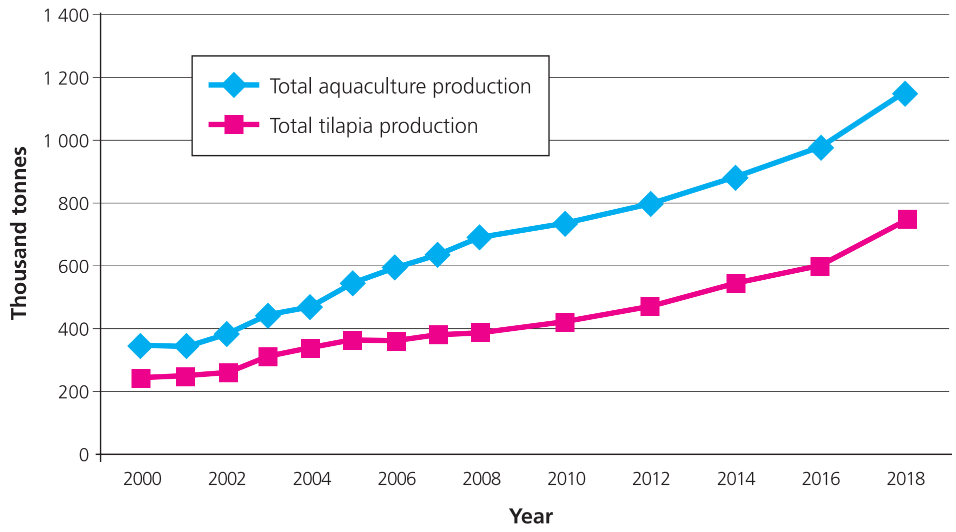
In addition to these recommendations, the Code of Practice for Good Animal Feeding (FAO, 1998) contains valuable information related to good feed manufacturing and feeding practices.

6. FUTURE PERSPECTIVES

As shown in this report, the production of farmed Nile tilapia in Egypt increased substantially between 1990 and 2008. It is very likely that aquaculture in general, and tilapia culture in particular, will continue to grow. However, suitable and available sites for tilapia culture development are being heavily exploited, leaving little room for future expansion. Therefore, tilapia culture expansion will depend on the optimum use of resources. This will require a gradual shift from the existing extensive and semi-intensive practices to more intensive production systems. This approach will inherently increase the dependence on manufactured feeds, thereby reducing the demand for organic and inorganic fertilizers.

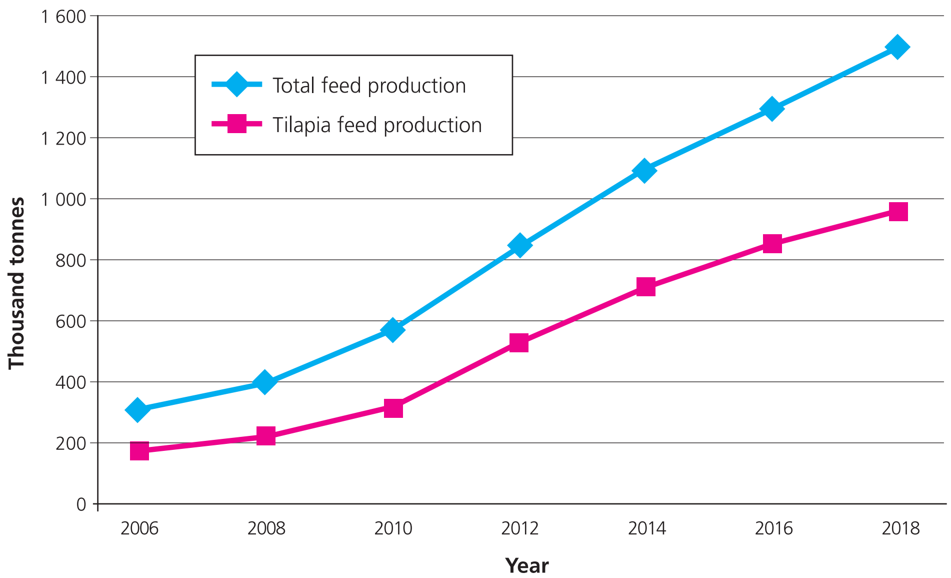
The aquaculture target of Egypt is to produce about 1 000 000 to 1 200 000 tonnes/year by 2018 (MALR, 2007) (Figure 14). This means that aquafeed production is expected to increase to about 1.5 to 1.7 million tonnes/year (Figure 15), assuming an FCR of between 1.2:1 and 1.5:1. The current contribution of tilapia production to total aquaculture production (56 percent) is expected to increase to 60 to 70 percent (due to intensification). Therefore, commercial tilapia feed production is expected to reach about 700 000 to 900 000 tonnes/year by 2018 (Figure 15).

FIGURE 14
Projected total aquaculture and tilapia production in Egypt until 2018



Source: GAFRD (2009); MALR (2007).

FIGURE 15
Projected total aquafeed and tilapia feed production in Egypt until 2018



Note: Tilapia feed production for this figure was calculated by the author based on the contribution of tilapia to total aquaculture production.

Sources: El-Sayed (2007); M.F. Osman, GAFRD, personal communication, 2009.

It is expected that there will be sharp competition for ingredients by the aquafeed and animal feed industries. Accordingly, the prices of feed ingredients in general, and imported ingredients in particular, will increase. Small-scale tilapia farmers are likely to be the most seriously affected groups. It is incumbent upon the government to develop action plans to deal with the potential crisis in the aquafeed industry. Special attention will have to be paid to small-scale tilapia farmers who might be enforced to abandon their traditional semi-intensive farming systems to the high input-demanding intensive system.

It is also expected that feed manufacturers will make greater and better use of non-conventional feed resources that are readily available and accessible in Egypt. Those manufacturers will also add production lines in their feed mills for larval and fingerling feed production. Fish nutrition researchers and specialists will also have to conduct more research on the use of non-conventional feed resources. It also expected that the government will impose more restrictions on quality control and inspection standards over feed ingredients, processed feed and produced fish.

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