



Food and Agriculture
Organization of the
United Nations

FIAA/C1130 (En)

FAO
Fisheries and
Aquaculture Circular

ISSN 2070-6065

SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN AFRICA



Main photo: Interviewing a small-scale cage farmer on Lake Volta, Ghana (Courtesy of G. Anane-Taabeah).

Top-down to right: Participation of women in pond construction, Ghana (Courtesy of E.A. Frimpong); Feed pelletizing machine given by the government to cluster farmers, Kenya (Courtesy of B. Nyandat); Tilapia seed production in hapas, Kenya (Courtesy of B. Nyandat); Manual feeding of tilapia ponds, Egypt (Courtesy of A.-F.M. El-Sayed); Sorting and weighing of tilapia harvest, Egypt (Courtesy of A.-F.M. El-Sayed); Fish vendor in a vegetable and fruit market, Egypt (Courtesy of A.-F.M. El-Sayed); Recipe for grilled tilapia published by a magazine, Nigeria (Courtesy of A.N. Atanda).

SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN AFRICA

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ISBN 978-92-5-109756-4

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PREPARATION OF THIS DOCUMENT

The document includes five papers on tilapia farming in Africa. The papers were based on case study reports submitted by tilapia experts, including: (i) Abdel-Fattah M. El-Sayed for the case of Egypt; (ii) Emmanuel A. Frimpong and Gifty Anane-Taabeah for the case of Ghana; (iii) Charles C. Ngugi, Betty Nyandat, Julius O. Manyala and Beth Wagude for the case of Kenya; (iv) Akintunde N. Atanda and Oyedapo A. Fagbenro for the case of Nigeria; and (v) Theodora S. Hyuha and her team for the case of Uganda. In order to make the entire document more coherent and succinct, the contents in the case study reports were reorganized and condensed by the editors. Readers may contact the experts for the original reports that contain more detailed information. Alio Andrew, Ana Menezes, Audun Lem, Derun Yuan, Fu-Sung (Frank) Chiang, James Miller, Kevin Fitzsimmons, Michael Phillips, Neil Ridler, PingSun Leung, Randall Brummett, Steve Amisah, Weimin Miao, Xinhua Yuan and Yongming Yuan are acknowledged for their valuable support to organizing the studies and/or review of the papers. Danielle Rizcallah, Maria Giannini and Marianne Guyonnet are acknowledged for their assistance in editing and formatting, and Ettore Vecchione is acknowledged for designing the front cover. The funding support to the case studies provided by the Swedish International Development Cooperation Agency through the New Partnership for Africa's Development-FAO Fish Programme is acknowledged.

FAO. 2017.

Social and economic performance of tilapia farming in Africa, edited by J. Cai, K.K. Quagraine and N. Hishamunda. FAO Fisheries and Aquaculture Circular No. 1130. Rome, Italy.

ABSTRACT

World tilapia aquaculture production grew 12 percent annually, from less than a half million tonnes in the early 1990s to over 5 million tonnes in the mid-2010s. Africa accounted for 20 percent of the growth. Yet most of the contribution came from Egypt, whereas in the mid-2010s countries in sub-Saharan Africa accounted for less than 20 percent of tilapia aquaculture production in Africa and less than 4 percent of the world production. In light of the potential fish demand driven by population and economic growth in Africa where tilapia is a native species favoured by most consumers, there is little doubt that there is great potential for the development of tilapia farming in Africa and in sub-Saharan Africa in particular. However, an appropriate development policy and sector management are needed to realize the potential. This collective volume includes five studies on tilapia farming in Egypt, Ghana, Kenya, Nigeria and Uganda, which together accounted for nearly 95 percent of Africa's tilapia aquaculture production in the mid-2010s. Each study provides a comprehensive account for the development of tilapia farming in the respective country with focus on the social and economic dimensions. Tilapia value chains are analysed in the context of the entire aquaculture or fish value chains from various perspectives (e.g. technical, economic, social and institutional). Issues, constraints and challenges are highlighted and discussed. Potential solutions are recommended. Despite the vast information and knowledge provided by the studies, there are still many unknowns about tilapia farming in Africa, especially on the economic performance. Further study is needed to fill the information and knowledge gaps.

ABBREVIATIONS AND ACRONYMS

ABW	average body weight
BCR	benefit-cost ratio
BMP	best/better management practice
CP	crude protein
DSIP	Development Strategy and Investment Plan
EEAA	Egyptian Environmental Affairs Agency
EIA	environmental impact assessment
EMCA	Environmental Management and Coordination Act
EPA	Environmental Protection Agency
ESP	Economic Stimulus Programme
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCR	feed conversion ratio
FDF	Federal Department of Fisheries
FFEPP	Fish Farming Enterprise Productivity Programme
FISH	Fisheries Investment for Sustainable Harvest
FTE	full-time equivalent
g	gram
GAFRD	General Authority for Fish Resources Development
GDP	gross domestic product
GHC	Ghanaian cedi
GNADP	Ghana National Aquaculture Development Plan
ha	hectare
HACCP	Hazard Analysis Critical Control Point
HIV/AIDS	human immunodeficiency virus/acquired immunodeficiency syndrome
kg	kilogram
km	kilometre
KNUST	Kwame Nkrumah University of Science and Technology
KSh	Kenya shilling
LE	Egyptian pound
LEAD	Livelihoods and Enterprises for Agricultural Development
m ²	square metre
m ³	cubic metre
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
n.a.	not applicable or not available
NaFIRRI	National Fisheries Resources Research Institute
NEMA	National Environment Management Authority
NGO	non-governmental organization
PPP	public-private partnership
ppt	parts per thousand
RAS	recirculating aquaculture system
SARNISSA	Sustainable Aquaculture Research Networks in sub-Saharan Africa
SSA	small-scale aquaculture
TC	total cost
TFC	total fixed cost
TSP	triple superphosphate
TVC	total variable cost
USAID	United States Agency for International Development
USD/US\$	United States dollar
USh	Uganda shilling
WAFICOS	Walimi Fish Farmers' Cooperative Society

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I. SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN EGYPT

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El-Sayed, A.-F.M. 2017. Social and economic performance of tilapia farming in Egypt. *In* J. Cai, K.K. Quagrainie & N. Hishamunda, eds. *Social and economic performance of tilapia farming in Africa*, pp. 1–48. FAO Fisheries and Aquaculture Circular No. 1130. Rome, Italy.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the Central Agency for Public Mobilization and Statistics, the General Authority for Fisheries Resources Development (Ministry of Agriculture and Land Reclamation) and WorldFish (Abbasa, Abu Hammad, Sharkia governorate) for assistance and providing information. Special thanks go to Dr Ismail Radwan (President of the Fish Farmers' Association at Kafr El-Shaikh) for providing his own private data and also for facilitating the author's visits to many fish farms and fish feed mills in Kafr El-Shaikh governorate. The assistance of the many fish farmers, fish feed millers, and fish wholesalers and retailers whom the author visited and interviewed is also highly appreciated.

1. COUNTRY PROFILE AND NATURAL RESOURCES

1.1 Country profile

Geography

Egypt is a subtropical country occupying the northeast corner of Africa and the Sinai Peninsula in Asia. Egypt is located between latitudes 22°–32° N and longitudes 25°–35.5° E. It is bounded on the north by the Mediterranean Sea (1 000 km long), on the west by Libya (1 115 km long), on the south by the Sudan (1 230 km long), and on the east by the Red Sea (1 200 km long) (Figure 1).

Figure 1: Map of Egypt



Source: https://commons.wikimedia.org/wiki/File:Egypt_administrative_divisions_-_Labels_-_colored.svg (with modification by the author).

Administrative regions

Egypt is divided into 27 administrative areas called governorates. The governorates are further divided into:

- **Urban governorates:** Alexandria, Cairo, Damietta (Domiati), Port Saied and Suez. Urban governorates are inhabited by 18 percent of the total population according to the 2012 census.

- **Delta governorates:** Dakahlia, Sharkia, Kaliobia, Kafr El-Shaikh, Gharbia, Minofia, Behaira and Ismailia. About 43 percent of the country's population inhabit the Delta region. About 60 percent of total agricultural land is found in this region and therefore agriculture is the main human activity in the Delta area.
- **Upper Egypt:** Giza, Bany Suif, Fayyum, Minya, Assut, Sohaj, Qina, Luxor and Aswan. About 37.5 and 32 percent of Egypt's population and agricultural lands, respectively, are found in Upper Egypt.
- **Border governorates:** Red Sea, New Valley (El-Wadi El-Gadeed), Marsa Matrouh, North Sinai and South Sinai. Although these governorates occupy about 85 percent of the country's area, only 1.5 percent of the total population inhabits the area.

Population

The estimated population of Egypt (excluding Egyptians living abroad) was 83.7 million in 2012 (CAPMAS, 2013), 40 percent of which was less than 15 years old, whereas the economic force (20–60 years old) accounted for 43 percent. The male to female ratio was approximately 1.04:1. About 80 percent of the population lived in rural areas. The most heavily populated governorates were Cairo, Giza, Sharkia, Alexandria, Dakahlia, Behaira, Kaliobia, Minya and Sohag, with more than 4 million people each. The average population density was 83.7 people/km².

Climate

Four climate seasons are recognized in Egypt:

- Winter (December–February): Rainy season. Rain is heavy on the Mediterranean coast and Delta areas. Winds are Northwest and the temperature ranges from 3–15 °C.
- Spring (March–May): Hot southerly winds (known as *Khamasin* winds) and dust storms of various directions. The temperature ranges from 15–25 °C.
- Summer (June–August): Dry and hot season with prevailing North winds. The temperature ranges from 30–37 °C.
- Autumn (September–November): Light winds (North, Northeast or Northwest winds). The temperature ranges from 15–25 °C.

1.2 Land and water resources

Land

The total area of Egypt is about 1 million km². Only about 7 percent of this area is populated and exploited, as the remaining 93 percent consists of deserts. In 2012, agricultural land reached 11 544 million feddans (4.81 million ha; one feddan = 0.42 ha) (CAPMAS, 2013). This area represented about 4.8 percent of the total area of Egypt.

Waterbodies

The Mediterranean Sea and Red Sea coastlines are about 1 000 km each, with a fishing area of about 2.8 and 1.8 million ha, respectively. Other sources include the Northern Delta lakes (Lake Manzala, Lake Borullus and Lake Edko); inland lakes (Lake Nasser, Lake Qaroon and Rayyan Valley); and coastal seawater lagoons (Port Foad Depression and Lake Bardaweel). Seawater, freshwater and brackish-water resources represent about 88 percent, 6.6 percent and 3.9 percent, respectively, of total water resources (El-Sayed, 1999).

Freshwater

The total freshwater sources in Egypt reached 64.39 milliard¹ m³ in 2011/2012 (CAPMAS, 2013). The Nile River and its tributaries are the main freshwater resources in the country. The Egyptian quota of the Nile water is 55.5 milliard m³/year, which represented 86.2 percent of total freshwater consumption in 2011/2012. Other sources, including underground water, agricultural and municipal wastewater, contributed 8.9 milliard m³.

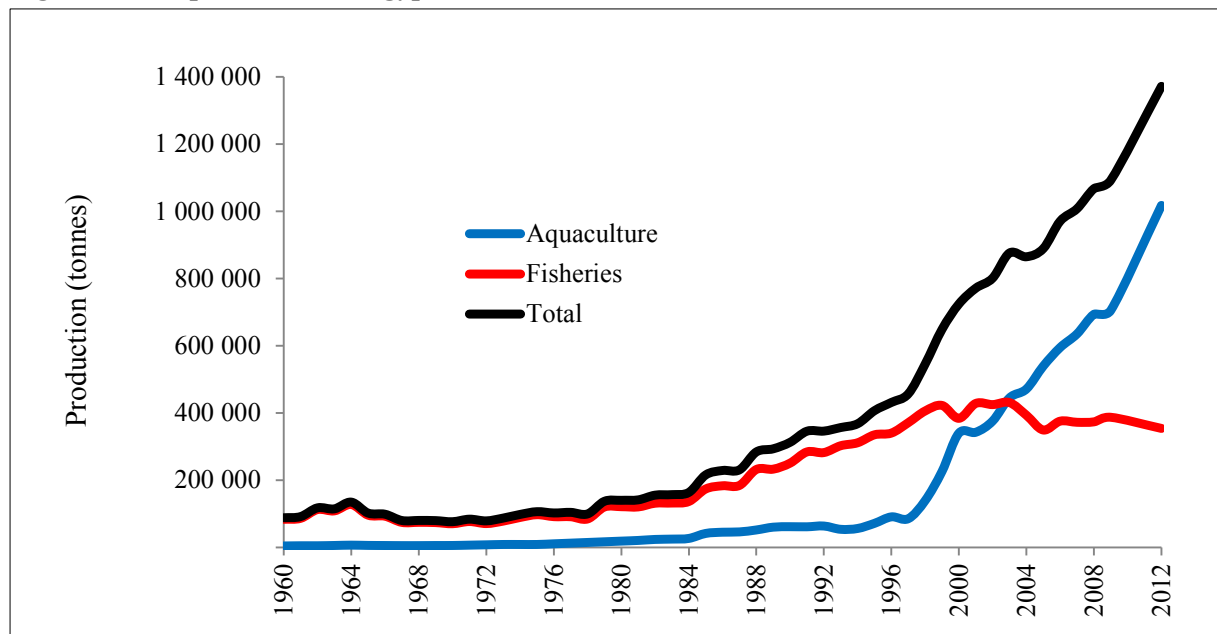
¹ One milliard = 1 000 million.

2. AQUACULTURE DEVELOPMENT IN EGYPT

Capture fisheries in marine, brackish-water and freshwater environments has a long history in Egypt. However, the annual production from capture fisheries has been nearly stable at about 300 000 to 400 000 tonnes during the past two decades. In 2012, capture fisheries production amounted to 354 238 tonnes, representing 25.8 percent of total fish production (1 371 976 tonnes) (GAFRD, 2014). Fishing is practised mainly in inland waters (36 percent of capture fisheries production), northern coastal lagoons (30 percent), Mediterranean Sea (20 percent) and Red Sea (14 percent) (GAFRD, 2013). Aquaculture, on the contrary, has been expanding at an outstanding rate during the past two decades.

Aquaculture has been practised in Egypt for human consumption since 2500 B.C. (Bardach, Ryther and McLaren, 1972). However, modern commercial aquaculture started in Egypt in the late 1950s, and from that time until 1998 the aquaculture industry grew at a steady rate. The industry witnessed high expansion and substantial development because of the accumulative efforts made by the government in the previous years. The growing attention to fish farming by the private sector has also helped the sector expand. As a result, farmed fish production increased from 139 389 tonnes in 1998, representing 25.5 percent of total Egyptian fish production, to 1 017 738 tonnes in 2012, contributing 74.2 percent to total fish production (Figure 2). In addition, Egypt is currently leading the aquaculture production in Africa. In 2012, Egyptian aquaculture production represented 61.8 percent of total African aquaculture (1 646 395 tonnes) (FAO, 2014), with farmed tilapia production contributing 83.6 percent to total farmed tilapia in Africa (FAO, 2014).

Figure 2: Fish production in Egypt



Sources: FAO (2014); GAFRD (2014).

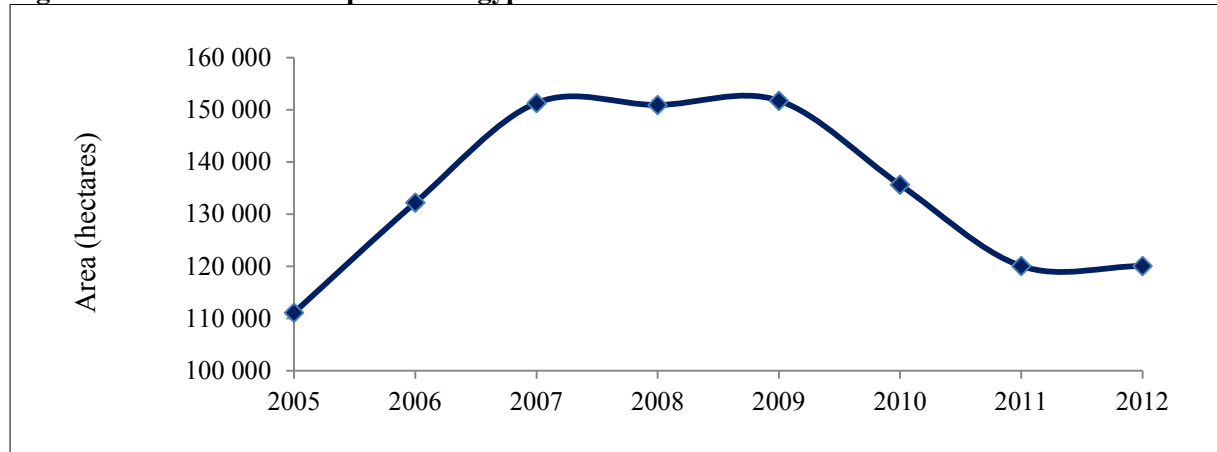
2.1 Aquaculture sites

The land used for aquaculture in Egypt is divided into three categories:

- Owned farms: private lands used for aquaculture by the owners themselves.
- Leased farms: state-owned farms leased to farmers by the General Authority for Fish Resources Development (GAFRD).
- Temporary farms: lands under urban or agricultural development and used temporarily for aquaculture.

In accordance with aquaculture expansion, the farmed area increased from about 42 000 ha in 1999 (El-Sayed, 1999) to 152 000 ha in 2009. This area, however, decreased to 120 000 ha in 2012 (Figure 3), mainly due to the reduction in leased areas, from 45 860 ha in 2009 to 24 812 ha in 2012 (GAFRD, 2014). The leased lands were taken away from farmers who failed to comply with the regulations of GAFRD or who failed to pay rental fees. Some of these areas have been converted to other activities. An analysis of satellite images has shown that the total pond surface in the Nile Delta area alone is about 104 000 ha (ALTERRA, 2010). These farms are generally fed with brackish water, primarily from the Northern Delta lagoons.

Figure 3: Total area of fish ponds in Egypt



Source: GAFRD (2014).

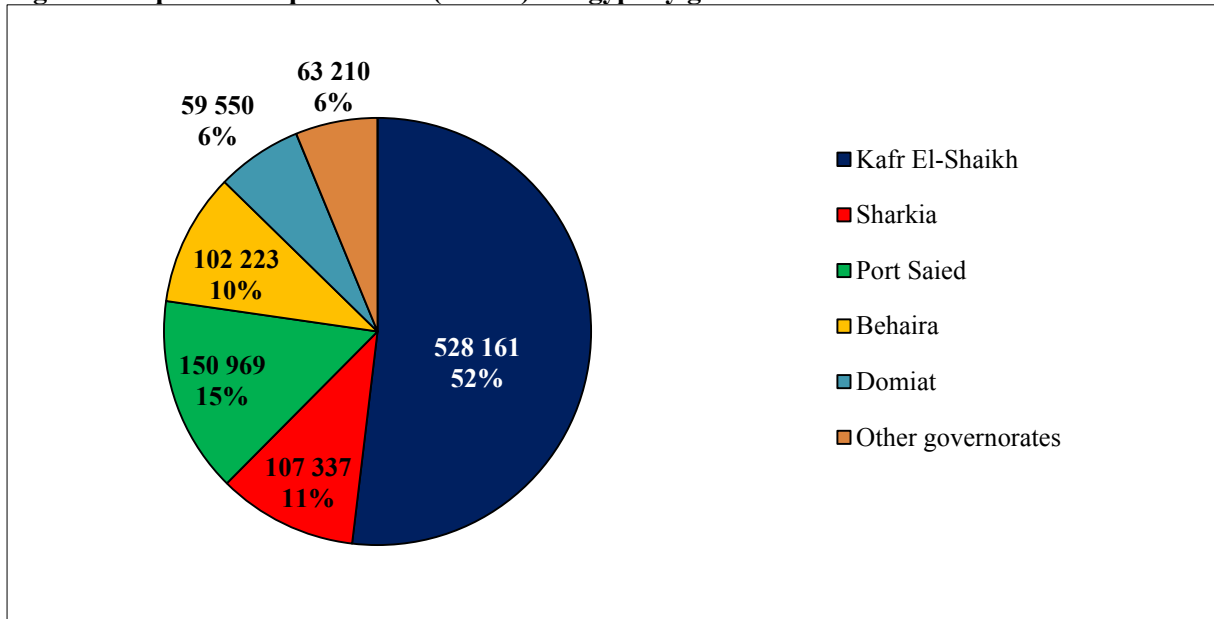
2.2 Freshwater and brackish-water aquaculture

Under Egyptian law, freshwater (mainly from the Nile and its branches and also from underground water) is not allowed to be withdrawn and used for pond aquaculture. Therefore, most aquaculture activities are practised in brackish water and centred in the Northern Nile Delta region (Figure 4).



Fish farms with earthen ponds are mostly clustered in the areas surrounding the four Delta lakes (also called Northern Delta lagoons): Lake Manzala, Lake Borullus, Lake Edko and Lake Maryut. It is no surprise, therefore, that the major aquaculture governorates are Kafr El-Shaikh, Port Saied, Sharkia, Behaira and Damietta (Domiat). These five governorates contributed 94 percent of total aquaculture production in 2012. Moreover, Kafr El-Shaikh alone produced

528 161 tonnes, representing 52 percent of total production in 2012. Other governorates, including Alexandria, Dakahlia, Fayyum, Gharbia, Ismailia, North Sinai and Suez, contributed only 6 percent of total production (63 210 tonnes) (Figure 5).

Figure 5: Aquaculture production (tonnes) in Egypt by governorate in 2012

Source: GAFRD (2014).

2.3 Marine aquaculture

Marine aquaculture is at its infancy in Egypt despite the great potential it may have. At the time of this writing, marine aquaculture production was almost negligible and restricted to a few species, namely seabass, seabream, mullets, meagre and shrimp. The main constraints facing the development of marine aquaculture in Egypt include:

- Lack of marine hatcheries and quality seeds: quality seed production of marine species is almost nil. Farmers mainly depend on seed collection from the wild.
- Lack of marine fish feed production: production of high-protein, high-lipid feeds for marine species, particularly during larval and nursery stages, lags far behind.
- Lack of skilled human resources: skilled personnel in marine fish breeding, hatchery management, larval rearing, fish fattening and extension services are lacking.
- High investment costs: the costs of marine aquaculture farms, including infrastructure, feed and seed supply, facility maintenance and other running costs, are especially high compared with the costs of freshwater culture facilities.
- Legislative problems: legislative complication results from the complexity of land lease regulations in the coastal areas and competition for land use as tourism takes priority. Marine species are therefore generally farmed in brackish-water environments.

2.4 Cultured species

Sixteen finfish species and one crustacean species (shrimp) belonging to twelve families were cultured in Egypt in 2012 (Table 1). Among these species, seven are freshwater species and nine are marine or brackish-water species. The dominant species are tilapia, carps and mullets, which represented 96 percent of the country's total aquaculture production in 2012 (Table 1).

Table 1: Aquaculture production by species in Egypt in 2012

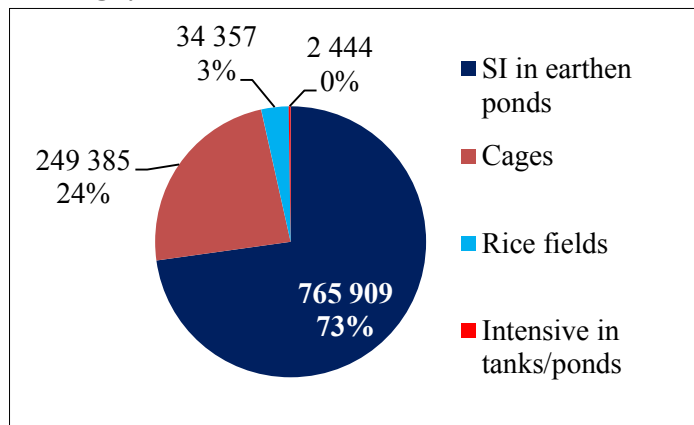
Family	Species (scientific name)	English name	Local name	Farming environment*	Farming system**	Production (tonnes)	Percentage of total production (%)
Freshwater species							
Cichlidae	<i>Oreochromis niloticus</i>	Nile tilapia	Bolti	FW/BW	SI/I, earthen ponds, tanks, cages	768 752	75.54
Cyprinidae	<i>Ctenopharyngodon idella</i>	Grass carp	Mabrouk Alhashayesh	FW/BW	SI, earthen ponds	67 065	6.59
	<i>Cyprinus carpio</i>	Common carp	Almabrouk Al-Ady	FW/BW	SI, earthen ponds		
	<i>Hypophthalmichthys nobilis</i>	Bighead carp	Mabrouk	FW/BW	SI, earthen ponds		
	<i>Hypophthalmichthys molitrix</i>	Silver carp	Almabrouk Alfiddi	FW	I, cages		
Clariidae	<i>Clarias gariepinus</i>	African catfish	Karmout	FW	SI/I, earthen ponds, tanks	13 622	1.34
Bugridae	<i>Bagrus bayad</i>	Bayad	Bayad	FW	SI, earthen ponds, tanks	613	0.06
Marine and brackish-water species							
Moronidae	<i>Dicentrarchus labrax</i>	European seabass	Karous	BW/MW	SI, earthen ponds, tanks	13 798	1.34
Mugilidae	<i>Mugil cephalus</i>	Flathead grey mullet	Bori	BW/MW	SI, earthen ponds, cages	129 651	12.74
	<i>Liza ramada</i>	Thinlip mullet	Tobara				
Sparidae	<i>Sparus aurata</i>	Gilthead seabream	Denis	BW/MW	SI, earthen ponds, tanks	14 806	1.45
Scianidae	<i>Argyrosomus regius</i>	Meagre	Loot	BW/MW	SI, earthen ponds	8 319	0.82
Penaeidae	<i>Peneaus</i> spp.	Shrimp	Gambari	BW/MW	SI, earthen ponds	1 109	0.11
Others						23	0.002
Total						1 017 738	100

Source: GAFRD (2014). *BW = brackish water; FW = freshwater; MW = marine water. **I = intensive; SI = semi-intensive.

2.5 Farming systems and practices

Aquaculture is practised mainly by the private sector, and contributed 99 percent of total aquaculture production in 2012 (GAFRD, 2014). In contrast, the 9 509 tonnes of aquaculture production (consisting mainly of tilapia, carps and mullets) from public farms contributed 1 percent of the total production (GAFRD, 2014). Semi-intensive culture in earthen ponds, which is usually practised in brackish-water environments particularly around the Northern Delta lagoons, is by far the most important farming system in Egypt (Figure 6). Semi-intensive production in earthen ponds sharply increased from 191 000 tonnes in 1999 to 765 909 tonnes in 2012, representing 75 percent of total aquaculture production (GAFRD, 2014). Intensive culture in cages, tanks and ponds, as well as fish cultured in rice fields, is also practised by the private sector (Figure 6).

Figure 6: Aquaculture production (tonnes) in Egypt by farming system in 2012



Source: GAFRD (2014).

Note: SI = semi-intensive.

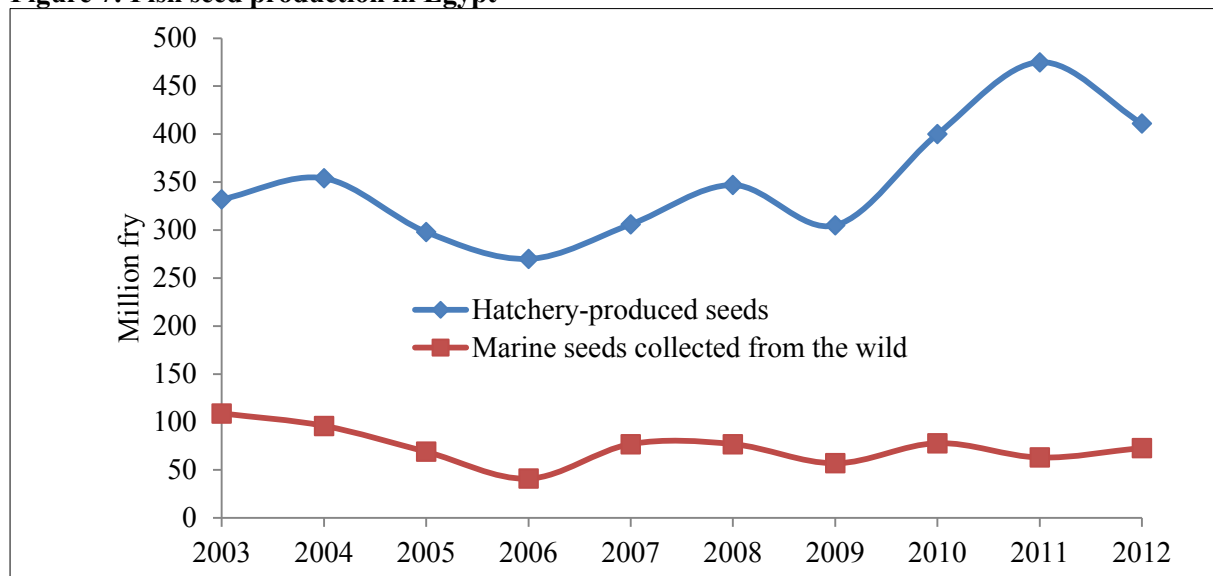
2.6 Hatcheries and seed production

Freshwater hatcheries

There are 12 government fish hatcheries (two of them for research activities) and 98 licensed private hatcheries (of which three are for marine species) (Macfadyen *et al.*, 2011). In addition, there are an estimated 500 operational but unlicensed private hatcheries, many of which have been established in recent years (Macfadyen *et al.*, 2011). The increase in hatcheries has helped keep seed prices down. For example, 2–3 week old tilapia fry (0.1–0.2 g/fish) typically cost about

LE 50 (US\$8) per 1 000 fry in 2012, while 1 000 fingerling tilapia (1–2 g/fish) cost about LE 200 (US\$32). The total number of hatchery-produced seeds fluctuated between 270 million and 475 million fry per year over the period 2002–2012 (Figure 7). Hatchery-produced seeds are primarily freshwater species, particularly tilapia and carps and to a lesser extent African catfish (Plate 1), as these fish reproduce successfully in captivity.

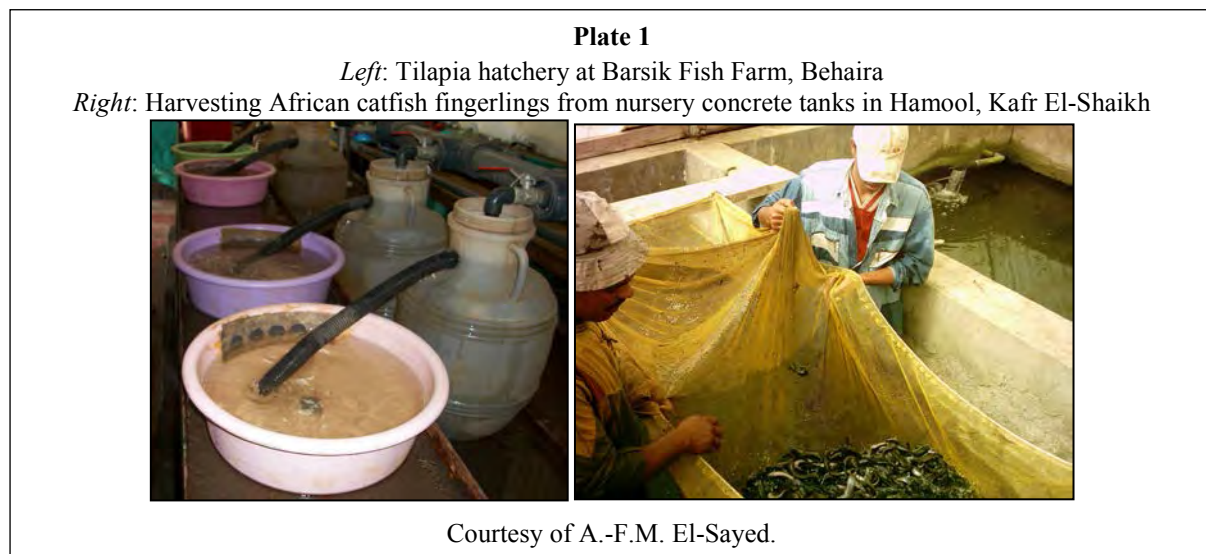
Figure 7: Fish seed production in Egypt



Source: GAFRD (2014).

All-male Nile tilapia currently represent a substantial proportion of farmed tilapia production. The vast majority of hatcheries produce monosex (all male) tilapia seed using oral administration of steroid hormone 17α -methyltestosterone. The hormone is generally incorporated into larval feeds at a dose of 30–60 mg/kg and administered to undifferentiated, swim-up larvae (5–8 days after hatch; 1–2 days after yolk-sac absorption) for 25–30 days (El-Sayed, 2006; El-Sayed, Abdel-Aziz and Abdel-Ghani, 2012). The process produces about 85 to 95 percent males. However, improper use of the hormone (e.g. using a higher amount than necessary or adopted without precaution or hygienic measurement) would lead to adverse ecological and human health impacts.

Tilapia broodstock and larvae are generally fed a diet containing relatively high protein levels (30–35 percent) compared with 25 percent protein diets commonly used during the rest of the production cycle (El-Sayed, 2006; El-Sayed, 2013).



Nearly all small-scale farmers buy tilapia seeds (both monosex and mixed sex) at a size of 2 to 5 grams from commercial hatcheries located in major tilapia production areas. Most large-scale tilapia farmers in Kafr El-Shaikh, Behaira, Sharkia and Port Saied produce both monosex and mixed-sex tilapia for their own use and 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 the farming season in May and June. Usually, farms produce only one crop annually, with the fish harvested in November and December or overwintered through December until March or April.

Many tilapia hatcheries have polytunnel greenhouses covering broodstock ponds or tanks. Because greenhouses insulate the ponds and retain the heat in the water, hatcheries can get breeding started earlier in the season or overwinter fry/fingerlings for early stocking. Some farmers use borehole water with a constant temperature or they use a boiler to heat the water. Hatcheries with greenhouses and boilers can advance spawning by six to eight weeks.

In 2012, the technical characteristics and economic performance of tilapia hatcheries were assessed (Nasr-Allah *et al.*, 2014). According to the assessment results, there are three main tilapia hatchery systems in Egypt: hapa-based in earthen ponds, hapa-based in greenhouse tunnels, and concrete tanks in greenhouse tunnels with water heating. About 96 percent of hatchery production is sold as fry, and only 4 percent of seed production is sold as fingerlings. Both the total costs and total revenues were the highest in heated greenhouse hatcheries, followed by greenhouse-based, and the lowest in hapa-based systems. The results also indicate that tilapia hatcheries face many problems, including shortages of good quality broodstock and water, poor water quality, high fuel costs, lack of access to finance, a ban on fry transport between governorates, and limited knowledge of best hatchery management practices.

A number of government carp hatcheries have also been constructed during the past decades. These hatcheries distribute carp seeds to farmers at low prices for farming mainly in rice fields. Private carp and African catfish hatcheries have been built recently to meet the increasing demand for, and expansion of, carp and catfish culture.

Tilapia and catfish broodstock are initially collected from the wild and used for seed production. They are used for a few years (3–4 years) and then replaced by new broodstock, typically selected from their progenies or collected from the wild. Carp broodstock (common carp, grass carp and silver carp) are domesticated ancestors of populations that have been introduced into the country from Asia. Hatcheries keep these broodstocks for 4–5 years and replace them with new broodstock from their progenies or from the wild.

2.7 Marine hatcheries and seed collection

The seeds of marine species (seabream, seabass, mullets, eels and meagre) are collected from the wild. Many fry collection centres are scattered along discharge canals connected to the Mediterranean Sea. Seed collection from the wild sharply decreased from about 109 million fry in 2003 to 73 million fry in 2012 (GAFRD, 2014). The decline was generally attributed to the overfishing of seeds and the poor collection, handling and transportation of fry, which led to subsequent mortality. In order to stop marine fry overfishing, GAFRD has recently issued Resolution No. 592/2012 as an amendment of Resolution No. 321/2012, which regulates the collection of marine fish seeds for aquaculture purposes.

At present, four marine hatcheries are producing marine seeds, but their production is insignificant in marine seed supply. The deficiency of marine fish seed supply (both hatchery produced and wild caught), together with increased demand, has sharply increased their prices.

3. TILAPIA AQUACULTURE IN EGYPT

3.1 Background

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 twentieth century (Pillay, 1990; El-Sayed, 2006). Attributes that make them excellent aquaculture species include fast growth, 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.

During the past two decades, global tilapia aquaculture has increased significantly and widely; more than 100 countries have tilapia farming in freshwater and/or brackish-water environments. As a result, global tilapia aquaculture production has increased from 383 654 tonnes in 1990 (2.28 percent of total aquaculture production) to 4 507 002 tonnes in 2012, representing 6.8 percent of global aquaculture (excluding aquatic plants) and 10.8 percent of total inland aquaculture (FAO, 2014). The average annual production growth rate during this period approached 13 percent.

Tilapia culture has traditionally been practised in Egypt for thousands of years. An Egyptian tomb frieze dating from about 2500 B.C. depicts a tilapia harvest and suggests that the 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-Bolock, 1976; El-Sayed, 1999).

Nile tilapia is currently the only cultured tilapia species in Egypt. A tilapia hybrid (Florida red tilapia) was introduced into Egypt in the 1980s, but rearing trials almost ceased in response to consumers'

dislike of the hybrid and preference for Nile tilapia. Consumers' dislike of red tilapia could be attributed to its colour (which is not preferred by Egyptian consumers). This colour also imprints it as a "farmed fish", as Egyptian consumers favour wild fish. It was during the 1990s that Nile tilapia was recognized as an important aquaculture species. This recognition was associated with the expansion of semi-intensive culture systems in earthen ponds, an expansion that was driven by private fish farmers and the development of privately owned hatcheries and feed mills.

Four major tilapia farming governorates (Kafr El-Shaikh, Port Saied, Sharkia and Behaira) accounted for over 90 percent of the 768 752 tonnes of tilapia aquaculture production in 2012. The governorates of Domiat, Fayyum, Ismailia and Dakahlia accounted for about 5 percent, while the remaining ones accounting for less than 3 percent of total farmed tilapia (Table 2).

Table 2: Major tilapia producers and production (tonnes) in Egypt in 2012

Governorate	Tilapia production (tonnes)	Share of total tilapia production (%)
Kafr El-Shaikh	455 000	59
Port Saied	99 590	13
Sharkia	83 589	11
Behaira	73 553	10
Domiat	16 697	2.2
Fayyum	11 579	1.5
Dakahlia	3 193	0.4
Ismailia	5 107	0.7
Others	20 444	2.7
Total	768 752	100

Source: GAFRD, 2014.

Nile tilapia is reared both semi-intensively in earthen ponds and intensively in cages, ponds, concrete tanks and recirculating systems. Tilapia are also raised in rice fields together with carps. The following sections briefly describe tilapia culture in these systems.

3.2 Semi-intensive culture of tilapia in earthen ponds

Pond preparation and maintenance

In Egypt, semi-intensive culture of tilapia in earthen ponds is practised mainly in brackish-water environments, particularly around the Northern Delta lagoons (Plate 2). Pond culture is practised primarily by the private sector, while the contribution of the government is rather limited. 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 about 1 metre.

A longitudinal ditch, about 50 cm deeper than the main pond, is usually dug at one side of the pond for fish wintering and harvesting. When the pond is drained, fish are forced to move into the ditch. Fish harvesters use nets to pull the fish to one end of the ditch where they can be removed with scoop nets (Plate 3).

Tilapia ponds are usually drained for harvesting and remain dry for about four months (from November/December to March/April). Most tilapia farmers harvest their crops in early winter (November/December) because the fish cannot tolerate a severe drop in water temperature during winter. However, some polyculture farmers extend the production cycle throughout the year.

Plate 2

Semi-intensive tilapia culture in earthen ponds in Egypt



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

Plate 3Fish wintering and harvesting ditch in Burollus,
Kafr El-Shaikh governorate

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

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 for pond preparation and maintenance being low is that most small-scale farmers do not have official rental or ownership contracts. Instead, they informally rent ponds from large-scale farmers or landowners at much higher rental rates than government rates. Therefore, these farmers are generally reluctant to add inputs to the ponds since they have unsecured tenure. The occasional removal of the mud layer and tilling of

the pond soil before pond filling are carried out in government tilapia farms. Very few private pond farmers till their ponds.

Tilapia monoculture

Monoculture of Nile tilapia (*Oreochromis niloticus*) in semi-intensive earthen ponds is the most important farming system in the country. It is widely practised in many governorates, especially in Kafr El-Shaikh, Port Saied, Sharkia and Behaira governorates. As noted earlier, all-male Nile tilapia currently represent a substantial proportion of farmed tilapia production. They are produced using an oral administration of 17 α -methyltestosterone. Tilapia are stocked at 24 000–48 000 fish per ha (5-30 gram fingerlings). Some farmers aerate their ponds using paddle wheels, especially at high stocking densities. The production varies from 7.5 tonnes to 15 tonnes/ha per production cycle (5-9 months). The high variation in productivity reflects variations in stocking density, fingerling size, pond and water management, type and quality of feed, and feeding regimes adopted. Fish size at harvest ranges from 200 to 300 grams. Some farmers stock overwintered fingerlings over 40 grams which can reach 500 to 700 grams at harvest (10–13 months).

Tilapia polyculture

Polyculture of tilapia with other species is commonly practised in Egypt. Typically, Nile tilapia, mullets (flathead grey mullet, *Mugil cephalus*, and thinlip mullet, *Liza ramada*) and carps (mainly common carp, *Cyprinus carpio*; grass carp, *Ctenopharyngodon idella*; bighead carp, *Hypophthalmichthys nobilis*; and occasionally silver carp, *Hypophthalmichthys molitrix*) are reared semi-intensively in a polyculture system in earthen ponds.

Polyculture of Nile tilapia, common carp and flathead mullet is the most popular system of production. The production of these three fish species from the semi-intensive system reached 686 537 tonnes

(tilapia 54.1 percent, carps 9.5 percent and mullets 5.9 percent), accounting for nearly 70 percent of Egypt's total aquaculture production in 2011.

The overall stocking density for polyculturing the three species ranges from 12 000 to 40 000 fish per ha. Tilapia is usually the target species, accounting for 75 to 90 percent of the fish stocked, yet stocking ratios between the three species vary considerably from one area to another and even from one farm to another within the same area. The stocking sizes of tilapia, mullets and common carp are usually 1–50 grams, 5–40 grams and 5–30 grams, respectively. The fish are stocked in April or May according to the water temperature. The yield ranges from 5 to 10 tonnes per ha per crop (5 to 10 months), depending on the stocking size, harvest size, fertilization and feeding regimes (Table 3).

It should be mentioned that mullets take about 13–16 months to reach market size; therefore, they are generally reared separately (overwintered) until they reach 10–50 grams and then stocked with tilapia so that both fish can be harvested at the same time.

Pond fertilization

Most semi-intensive tilapia farmers in Egypt do not use organic or inorganic fertilizers. Instead, they use processed feed, mainly 25 percent crude protein (CP) compressed feeds, throughout the whole production cycle. About one third of farmers apply organic or inorganic fertilizers in addition to supplemental feeding. Some of these farmers fertilize their ponds only once prior to fish stocking and feed their fish commercial pellets for the entire production cycle; others apply organic or inorganic fertilizers regularly (at certain intervals) when the productivity of the ponds decreases.

Poultry manure is the most commonly used organic fertilizer for tilapia pond fertilization. Fertilization rates range from 2–4 tonnes/ha per production cycle. In general, before filling the ponds, farmers spread dry poultry manure on the pond bottom. Other farmers pile dry manure on the pond dykes and spray it with water for a few days before washing it into the ponds (Plate 4). Farmers usually buy manure from nearby poultry farms, but they may also collect droppings from their own poultry pens to use for pond fertilization.

Urea and superphosphates are commonly used as inorganic fertilizers in pond fertilization. The application ratios and amounts of these fertilizers vary considerably between farmers and farming areas. Application rates range from 20 to 40 kg of superphosphates per ha and from 10 to 20 kg of urea per ha (Table 3).

Plate 4

Poultry manure piled on the pond dyke in Hamool, Kafr El-Shaikh



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

Feeding and feed management

Hand feeding twice a day (once in the morning and once in the afternoon) is the most common feeding practice among semi-intensive tilapia farmers in Egypt (Plate 5). Farmers who hand feed generally do not feed their fish at a calculated percent of fish body weight per day. Instead, they provide a given amount of feed based on previous experience.

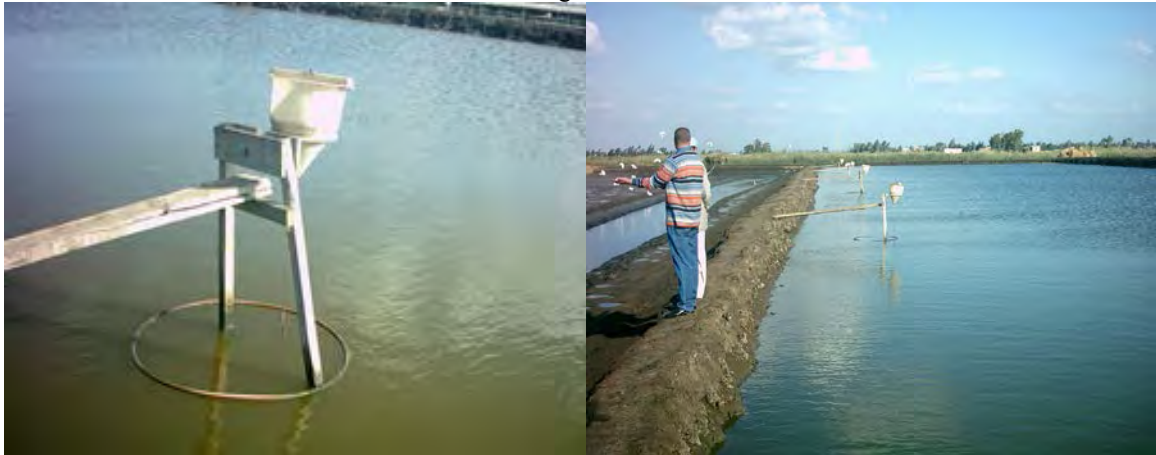
Plate 5
Manual feeding of tilapia ponds in Behaira



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

The use of locally made and cheap demand feeders (Plate 6) has become increasingly popular, especially among medium and relatively large-scale farmers. A typical demand feeder used in the country comprises 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 10–15 cm under the water surface. When the fish touch or activate the rod, feed pellets slowly drop on the water surface. The application of such feeders enables the fish to eat only when they need to. Between 10 and 15 feeders per hectare are deployed at fixed distances along the pond sides (El-Sayed, 2013).

Plate 6
Demand feeding in Kafr El-Shaikh



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

Table 3: Farming performance under various feed and fertilization strategies for semi-intensive tilapia farming

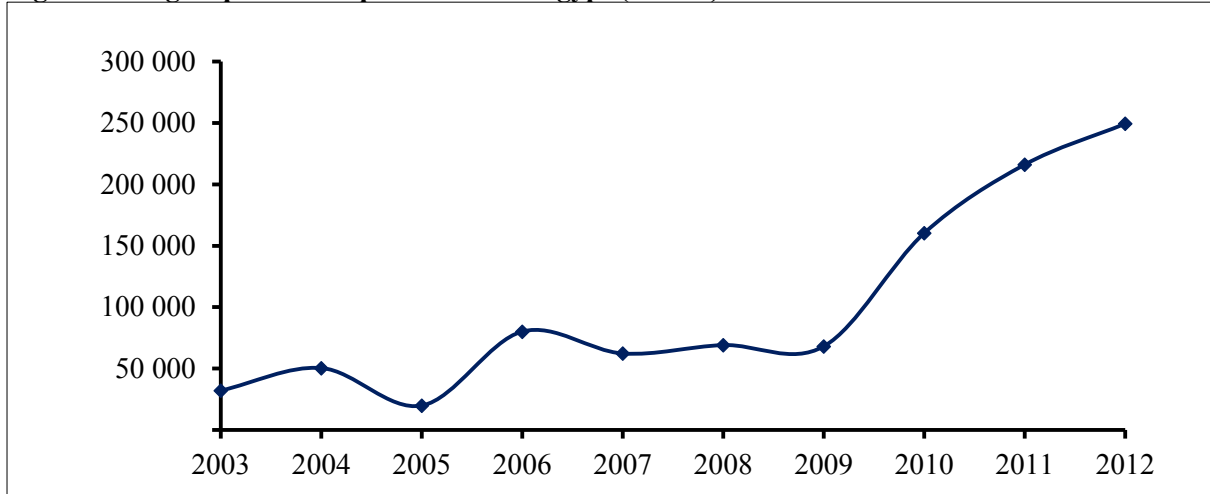
Farming species	Stocking size (g)	Density (fish/ha)	Fertilization regime	Feeding	Culture period (days)	Yield (tonnes/ha/crop)	Remarks	Reference
Nile tilapia (male)	1–3	20 000	Chicken manure, 1 000 kg/ha/week for 60 days; 54.4 kg urea plus 92.4 kg superphosphate/ha/week	(1) Feeding starts at day 60; 25 percent CP diet; 3 percent of BW per day (2) No feeding	145	(1) 4.17 (2) 3.20	African catfish (59 g) used for controlling overpopulation of tilapia. Yield includes tilapia reproduction and extraneous fish harvest.	Green, El Nagdy and Hebicha (2002)
Nile tilapia Silver carp Common carp	13.8 1.9 10.7	30 000	750 kg chicken litter/ha, biweekly application, plus 100 TSP and 20 kg urea/ha	Feeding starts 6 weeks after stocking; 25 percent CP diet; 3 percent BW/day	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	18–20	10 000	50 kg/ha chicken manure or 60 kg/ha grass compost	Fertilized ponds were not fed, while the control pond was fed with 25 percent CP diet	139	2.2–4.6 (per year)	Pellet-fed group was stocked at 20 000 fish/ha. Growth rates were not significantly different. The net yield was higher in pellet-fed ponds.	Muendo <i>et al.</i> (2006)
Nile tilapia (85 percent) + Catfish (15 percent) + 300 Silver carp	0.3 132 100	30 000 to 50 000	Chicken litter (550 kg/ha/week) or monophosphate (72.5 kg/ha/week) and urea (45 kg/ha/week)	Feeding starts 60 days after stocking; 25 percent CP floating pellets, twice a day, to satiation	190	4.9–8.6	With equal nutrient inputs and stocking densities, manure-fertilized ponds could perform equally well as pellet-fed ponds.	El-Naggar, Ibrahim and Abou Zead (2008)
Nile tilapia + Silver carp + Flathead mullet	5.0 5.0 5.0	35 000 5 000 10 000	Weekly; compost at 125 kg/feddan; cattle manure at 425 kg/ha; chicken litter at 425 kg/ha or 5 kg urea + 20 kg TSP/ha	Supplemental feed (25 percent CP) added to all treatments at 5 percent BW/day	150	4.75		Ahmed and Hassan (2011)
Nile tilapia Thinlip mullet	10 40	24 000 5 200	Weekly, poultry manure at 500 kg/ha	Ad libitum feeding of supplemental feed (25 percent CP)	180	7.2	African catfish (100 g) used for controlling overpopulation of tilapia.	A.-F.M. El-Sayed, personal survey (2013)
Nile tilapia Thinlip mullet	12 9	21 600 4 800	Biweekly, poultry manure at 1 250 kg/ha	Ad libitum feeding of pressed feed (25 percent CP)	240	9.0		A.-F.M. El-Sayed, personal survey (2013)

Notes: CP = crude protein; BW = body weight; TSP = triple superphosphate.

3.3 Intensive culture of tilapia in floating cages

Fish culture in floating cages has been spreading in Egypt at an outstanding rate during the past decades, particularly in the Domiat (Damietta) and Rashid branches of the Nile River. The number and area of cages has also dramatically increased. In 1996, only 578 cages covering about 171 960 m³ were in use (El-Sayed, 1999). By 2012, however, the number of cages had increased to 37 371 covering 18 353 875 m³ (GAFRD, 2014). As a result, cage aquaculture production increased from 32 000 tonnes in 2003 to 249 385 tonnes in 2012, representing 24 percent of total aquaculture production (Figure 8).

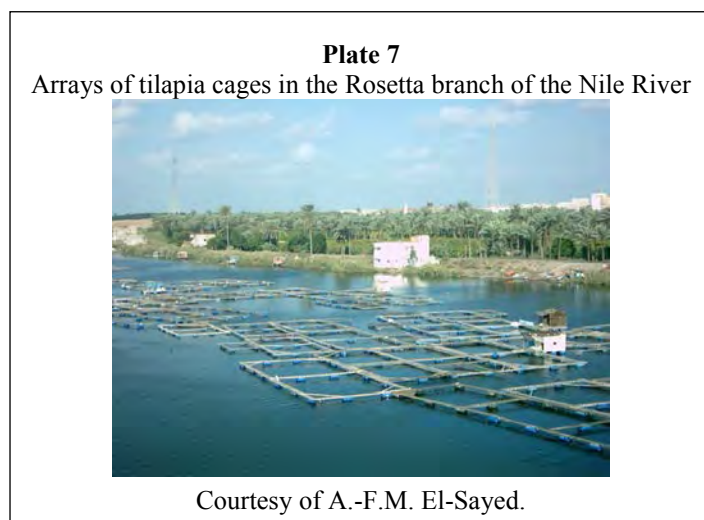
Figure 8: Cage aquaculture production in Egypt (tonnes)



Source: GAFRD, 2014.

Cage culture is practised exclusively by the private sector, particularly in Kafr El-Shaikh and Behaira governorates, which contributed 98 percent (74 percent in Kafr El-Shaikh and 24 percent in Behaira) to total cage production. Limited amounts (2 percent) were produced in Dakahlia, Domiat (Damietta) and Fayyum governorates.

Rectangular or square cages measuring 32 m³ (4 × 4 × 2 m) to 600 m³ (10 × 10 × 6 m) are commonly used. The cages are primarily made of wooden frames and synthetic netting. Empty, closed plastic barrels (50 litres) are fixed underneath the frames to serve as floats (8–12 floats per 600 m³ cage). The cages are used in the Nile (Rosetta branch) in groups or arrays (Plate 7). Professional divers are occasionally employed to monitor the cages, remove the fouling, and repair any damage that may occur to the nets.



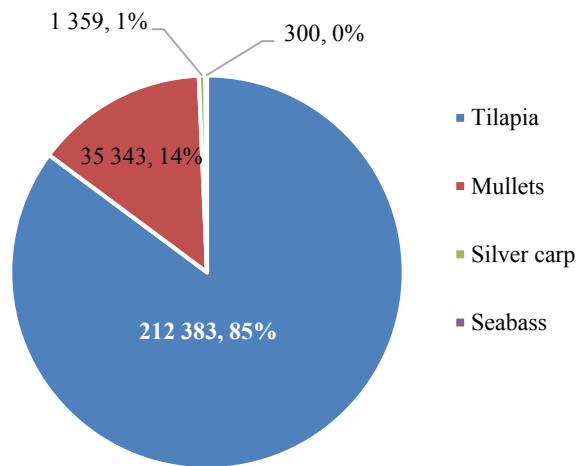
Until 2008, cage culture focused exclusively on Nile tilapia and mullet production. In 2009, cage culture of silver carp, in addition to tilapia and mullets, started, particularly in the southern part of Rosetta (Rashid) branch of the Nile River where the water is fresh and suitable for carp culture. As a result, the production of tilapia declined in just two years, from 69 108 tonnes in 2008, representing 100 percent of cage production and 18 percent of total tilapia production, to 59 000 tonnes in 2011, representing 27 percent of cage production and only 9.6 percent of total tilapia production.

On the other hand, carps and mullets contributed 136 878 tonnes (64 percent) and 20 000 tonnes (9 percent), respectively, to total cage production (GAFRD, 2014). However, in 2012, cage carp production sharply declined to only 1 359 tonnes, while tilapia production increased to 212 383 tonnes, representing 85 percent of total cage culture production (Figure 9) (GAFRD, 2014). This has been attributed to the low prices and the non-acceptance of silver carp in Egyptian markets. The sensitivity of silver carp to weather conditions, especially the high water temperature and low oxygen content during the summer season, renders it vulnerable to stress, disease and mass mortality.

Nile tilapia fingerlings of various sizes (5 to over 50 grams) are stocked in cages at a density varying from 60 to 100 fish/m³. The fish are fed with commercial extruded pellets (initially 2–3 mm in size, 30–35 percent CP, then reduced to 25–30 percent CP during fattening periods). If large sized (30–50 grams) overwintered fingerlings are stocked, they are usually fed with 4–5 mm pellets during the last 2–3 months of the fattening stage. The diets are generally offered manually, two to three times per day.

The feed conversion ratio (FCR) of extruded feed for cage cultured Nile tilapia raised in Egypt ranges from 1.2 to 1.5 for fingerlings and from 1.0 to 1.3 for the fattening stage (A.-F.M. El-Sayed, personal survey, 2013). Some farmers use the young-of-the year (5–10 grams), while others stock overwintered fish (30–50 grams). After 6–9 months, farmed young-of-the year tilapia reach about 300–500 grams in weight, with a total production ranging from 25–40 kg/m³ (about 15–25 tonnes per 600 m³ cage). Overwintered fish take about 4–6 months to reach 300–500 grams in weight depending on the initial stocking weight.

Figure 9: Species composition of cage aquaculture production (tonnes) in Egypt in 2012.



Source: GAFRD, 2014.

In the northern part of Rosetta branch of the Nile (closer to the river mouth where the water is brackish), only tilapia and mullet cage culture is practised. Tilapia fingerlings (5 grams) and flathead mullet (*Mugil cephalus*) or thinlip mullet (*Liza ramada*) fingerlings (3–4 grams) are stocked at relatively low density (about 30 fish/m³; 15 tilapia and 15 mullets). At the time of this writing, a common practice of cage farmers was to directly use feed ingredients such as corn flour, wheat bran, rice bran, bakery wastes and macaroni industry wastes (Plate 8). The practice not only resulted in relatively low yields (1–2 tonnes of tilapia and 2–3 tonnes of mullet per 400 m³ cage; i.e. 7.5–12 kg/m³), but also affected the water quality, such as causing increasing ammonia concentration, especially in the deep water layers.²

3.4 Intensive tilapia culture in earthen ponds

Intensive tilapia culture in earthen ponds is slowly spreading to some areas in Egypt, especially in newly reclaimed desert areas where the culture water is subsequently used for land crop irrigation. Ponds are usually aerated using air compressors, water splash or paddle wheels. In addition, the fish depend exclusively on formulated feeds and no fertilization is applied.

² Information from personal communication with a cage fish farmer (M. Turk) in Rosetta in 2013.

Plate 8

Bakery waste hung inside a cage to feed tilapia and thinlip mullet in the Rosetta branch of the Nile River



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

Nile tilapia fingerlings (2–20 grams) are stocked in ponds in April/May (depending on water temperature) at a density of 50 000–100 000 fish/ha. The fish grow to 200–250 grams in 5–8 months. Some farmers stock overwintered tilapia (average weight over 30 grams), which grow to about 300 to 400 grams in 5–9 months. The fish are fed with sinking or floating feeds (25–35 percent CP). Generally, 30–35 percent CP diets are used during the fingerling stages of production; these levels are reduced to 25 percent CP during the grow-out phases. Most of the farms use demand feeders; however, hand feeding (twice per day) is still practised in some areas.

The FCR attained using pelleted feeds ranges from 1.3:1 to 1.9:1 for fingerlings, and from 1.2:1 to 1.5:1 for the grow-out stage. In contrast, the FCR attained using extruded feeds ranges between 1:1 and 1.4:1 for fingerlings and between 1:1 and 1.2:1 for the grow-out stage. The total production at harvest ranges from 15 to over 20 tonnes/ha per crop, depending on the stocking size and density, feed and feeding regime, pond management and the culture period. Methods used for harvesting tilapia in intensive pond systems are similar to those applied in semi-intensive pond culture.

In one intensive tilapia farm in Edku (Behaira governorate), the farmer stocks all-male Nile tilapia fry at a density of 17 fish/m² (170 000 fish/ha). The ponds are aerated with paddle wheels with partial water replacement. The fry are usually fed with extruded feed (32 percent CP, but reduced to 25 percent CP during fattening stages). After 12 months, the harvest reaches 29 tonnes/ha (Ashour and Ashour, 2013).

3.5 Intensive tilapia culture in concrete tanks

Intensive tank tilapia culture in Egypt is slowly growing, especially in arid and semi-arid areas where freshwater or brackish water is limited (Plate 9). Tanks are rectangular or round, and a smaller size than earthen ponds and constructed mostly of concrete. The size and shape of tilapia culture tanks are variable and depend on the culture objectives. Most of the tilapia farmers using concrete tanks raise only all-male Nile tilapia. Fish are stocked at densities that range between 25 and 100/m³, depending on the initial stocking size. Tanks are aerated with air compressors (0.5–1 horsepower, depending on tank size and stocking density), paddle wheels (Plate 9) or water spraying over the tank surface. Tank water is partially replaced with freshwater when the water quality deteriorates.

Some tilapia farmers stock the fish (2–5 grams) in tanks in May/June and harvest 200–250 grams fish after 5–7 months. Other farmers stock overwintered fingerlings (30–60 grams) and harvest 300 to 500 gram fish in 6–9 months (El-Sayed, 2013). The total production of tank-cultured tilapia at harvest ranges from 10 to 30 kg/m³ depending on stocking density and culture period.

Tilapia are harvested by draining the water from tanks, mainly by gravity. Usually, tanks have a slight slope towards draining points to facilitate water draining. Fish are harvested by scoop nets. Tank-raised tilapia are mainly fed with commercial extruded feeds (35 percent CP at the beginning and reduced to 25–30 percent CP during the fattening stages). Hand feeding is generally used, as tanks are smaller than ponds and easier to distribute feed by hand. Typically, feed is offered two to three times per day. The FCR ranges between 1.3:1 and 1.7:1 for fingerlings and between 1.2:1 and 1.5:1 for the grow-out stage.

Plate 9

Tank tilapia culture in Salhia, Sharkia governorate, Egypt.



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

3.6 Integrated tilapia culture

Rice-fish farming

Rice is widely cultivated in Egypt as a major food crop. About 0.6 million ha of agricultural land were cultivated with rice in 2012 (CAPMAS, 2013). The potential of rearing fish in rice fields in an integrated system is increasing. Rice-fish farming has attracted the attention of many rice farmers in recent years and has been very successful. As a result, the production of fish in rice fields increased from 10 000 tonnes in 1999 to 35 107 tonnes in 2011, representing 4 percent of total aquaculture production (GAFRD, 2012). This amount has been produced exclusively from the Delta governorates (Behaira, Kafr El-Shaikh, Sharkia, Gharbia, Dakahlia and Domiat). Common carp, tilapia and African catfish are currently the only fish species reared in rice fields. However, the overall average of fish production per hectare is still relatively low.

One or more ditches (about 50 cm deep and 100 cm wide) are generally dug along the rice field and used as a nursery and refuge for the fish. Because the rice-growing period is not sufficient to produce market size fish, juvenile fish reared in rice fields are subsequently transferred to other aquaculture systems for fattening. When the rice field is drained for harvesting, the fish are segregated in the ditches where they can be easily collected.

Growing wheat or Egyptian clover (barseem) in fish ponds

In Egypt, fish (tilapia) farmers harvest their fish crops during November and December because the water temperature in the winter is unsuited for fish culture. Fish farmers in some areas use their ponds during the winter season (December to March) for growing winter crops such as wheat or barseem (Egyptian clover). In the case of wheat, when the crop ripens, farmers sometimes do not harvest it but leave it as a natural food source for fish (El-Sayed, 2007).

After the fish harvest, a crop of wheat is sown on the pond bottom and left to grow. This system proves to be highly productive and the most water efficient. Therefore, other farmers have begun to use the method, especially those in Kafr El-Shaikh governorate (Plate 10). In one study, wheat showed good growth and harvest with an average of 5.4 tonnes/ha using only the water remaining on the pond bottom without any fertilization (van der Heijden, 2012). Similarly, El-Gendy and Shehab El-Din (2011) evaluated the culture of monosex tilapia with barseem (Egyptian clover), wheat and barley in an alternative way. The study included raising tilapia as a single crop in one feddan (0.42 ha) earthen ponds, or growing barseem, wheat or barley in ponds that were previously stocked with 2, 4 and 6 fish/m² in a rotation. The authors found that growth rates and health conditions (lower parasitic count) of fish reared in ponds previously planted with barseem, wheat or barley were better than those of tilapia reared unitarily. The increase in the average weight of tilapia reared in barseem, wheat and barley fields were 20, 16 and 11 percent, respectively.

Integrating fish with fruits and vegetable agriculture has also been successful and economically cost-effective (van der Heijden, 2012). Increasing water use efficiency through integrating agriculture and aquaculture is possible. This approach can also lead to a considerable reduction in the use of inorganic fertilizers and in turn increase farm income through increasing productivity per unit of water. However, understanding the relationship between water requirements for both fish ponds and crop irrigation is necessary in order to optimize water use efficiency in integrated farming systems.

Intensive aquaculture systems as first users of water before other agricultural purposes deserve serious consideration because of their water use efficiency and fertilizing effect. However, integrated aquaculture systems have a number of constraints including: (i) farmers are not allowed to use irrigation water in aquaculture; (ii) land contracts may not allow integrated aquaculture; (iii) the concept and benefits of integrated aquaculture with land crops have not been well disseminated to or received by farmers; and (iv) farmers generally prefer traditional farming systems to the “risky” systems. These issues should be tackled by decision-makers in order to promote aquaculture-agriculture integration.

Plate 10

Growing (*left*) and harvesting and threshing (*right*) a wheat crop grown in tilapia ponds in Kafr El-Shaikh governorate



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

Integrated agriculture-aquaculture in the desert

Integrated aquaculture-agriculture in Egyptian deserts has been expanding rapidly in recent years. A large number of desert landowners have established integrated fish rearing facilities with their traditional land/animal crops. Currently, more than 100 intensive rural tilapia farms and 20 pioneer commercial fish farms are integrated with the agriculture irrigation system and animal production using underground water in the Egyptian desert (Abbas, Ali and Kenawy, 2008; Sadek, 2011). In this system, underground water with a salinity of 2–4 ppt can be used to irrigate land crops (such as corn, alfalfa/Egyptian clover, vegetables, fruits and flowers) along with fish monoculture or polyculture (tilapia, carps and mullets). Integrated systems are particularly attractive to farmers because water sources enriched with organic fish wastes from aquaculture ponds serve as a fertilizer for land crops and provide water for breeding sheep and goats. This system is considered a multicrop system, as it produces three different crops from the same quantity of water (Sadek, 2011).

Saltwater fish farming in Egyptian deserts is also potentially high. Innovative research and projects are currently being undertaken by the private sector to develop aquaculture-agriculture integration based on saltwater fish farming with encouraging results. Sadek (2011) reported that the irrigation of *Salicornia* crops combined with intensive European seabass and gilthead seabream aquaculture in underground brackish water (> 25 ppt) was successful and economically feasible. However, more research is needed to develop integrated aquaculture-agriculture in the desert.

4. ECONOMIC PERFORMANCE OF TILAPIA AQUACULTURE IN EGYPT

4.1 Capital and variable costs

The costs for establishing an intensive fish farm in Egypt are extremely high, ranging between US\$103 200 and US\$124 800 per hectare for the construction of tanks and between US\$33 600 and US\$50 400 per hectare for equipment (Naziri, 2011). The annual depreciation of the initial investment is also large, ranging from 5 to 10 percent. In desert areas, the additional cost of drilling a deep well can cost as much as US\$26 000 per well (Naziri, 2011). For earthen ponds, the construction cost is much lower, estimated at about US\$1 000 per hectare, with equipment costing about US\$800 (Naziri, 2011). However, it should be emphasized that the costs can vary considerably from one area to another depending on the farm size, the type of construction and equipment required, and the availability of inputs required.

Generally speaking, the operating costs of fish farming represent more than 95 percent of the total production costs in semi-intensive production systems, with the remaining 5 percent representing the construction and equipment depreciation. In intensive tank systems, running costs represent about 80 percent of the total costs; the remaining 20 percent represents the construction and equipment depreciation (Naziri, 2011).

Feed costs represent 75–90 percent of the operating costs based on the farming system adopted (El-Sayed, 2014). Seeds account for 2–8 percent of the total variable costs, depending on the initial stocking density and fingerling size. However, in a recirculating system in Kafr El-Shaikh where the stocking size was 250 g/fish, the seed costs represented 56 percent of the variable costs. Labour also represents a significant proportion of the operating costs, ranging from 4 to 13 percent. In general, the labour cost is higher in semi-intensive than in intensive farms because the former are more labour intensive. It should be emphasized that operating and fixed costs are currently higher than the values reported above due to inflation, the increase in costs of farming inputs, and the recent depreciation of the Egyptian pound against the United States dollar.

4.2 Revenue and profit

The costs and benefits of tilapia farms vary considerably and are dependent on the culture system adopted, the availability and costs of inputs, and the geographical region. The average costs and benefit-cost ratio (BCR) associated with tilapia culture in semi-intensive and intensive farming systems are summarized in Table 4.

All farming systems in Table 4 appear cost-effective with varying degrees of profitability. In semi-intensive systems, the BCR ranged from 1.3 to 1.5. Intensive culture in ponds and cages exhibited much better BCR. This is presumably due to the better access that intensive tilapia farmers have to funds, technology and production inputs; thus, they can operate systems with much higher operational and capital investment. This in turn would lead to better management and higher gross revenue and better BCR. In contrast, small-scale, semi-intensive farmers do not have regular access to funding and production inputs, and as a result total costs, revenue and BCR are generally low. However, the practice is still very profitable to farmers. The total costs are much higher in tank culture and recirculating aquaculture systems (RAS) than in cage and pond culture, leading to relatively low BCR compared with cage and pond intensive tilapia farming.

Table 4: Economic performance of tilapia farming in Egypt

Costs and returns (US\$)	Semi-intensive pond systems			Intensive systems			
	Farm 1*	Farm 2** (Behaira)	Farm 3*** (Kafr El-Shaikh)	Earthen ponds**	Cages (Rosetta, Behaira)**	Concrete tanks (Sharkia)**	RAS (Kafr El-Shaikh)****
Farm size	8.3 ha	4.2 ha	2.1 ha	NA	600 m ³	4.2 ha	140 m ³
Total variable costs (TVC)	14 664	5 545	10 652	12 200	14 756	19 336	7 704
Seeds	606	110	856	273	262	545	4 333
Feeds	12 000	3 636	7822	10 000	13 630	16 364	2 327
Protein content (%)	25	25	30	25	25–30	30–35	30–32
Price of feed (US\$/tonne)	500	550	684	500	620–680	684–896	684–704
Fertilizers	991	272	Not used	Not used	Not used	Not used	Not used
Labour	629	727	1 132	727	364	727	522
Energy and fuel	255	–	481	–	–	700	522
Miscellaneous costs	183	800	361	1 200	500	1 000	–
Total fixed costs (TFC)	543	1 680	420	1 680	300	2 680	486
Depreciation	366	NA ¹	270	NA	300	1 000	486
Construction depreciation	123	NA	120	NA	NA	NA	NA
Equipment depreciation	243	NA	150	NA	NA	NA	NA
Land use cost (rental)	177	1 680	150	1 680	NA	1 680	NA
Total costs (TC) = TVC + TFC	14 841	7 225	11 072	13 880	15 056	22 016	8 190
Total gross revenue (GR)	21 221	9 600	16 068	24 000	29 000	32 000	11 230
Net return (NR) = GR – TC	6 014	2 375	4 996	10 120	13 944	9 984	3 040
Benefit-cost ratio (BCR) = GR/TC	1.40	1.33	1.45	1.73	1.93	1.45	1.37

Notes: Values in US\$/ha/production cycle, unless otherwise indicated. Values were originally reported in local units (area in feddans and values in Egyptian pounds); and the author converted the areas into hectare (ha) and the values into United States dollars (US\$1 = 5.94 Egyptian pounds in 2011 and 6.60 in 2013). Farm size measured in hectare, except for cages and recirculation aquaculture systems (RASs), where m³ were used as a unit area. *Naziri (2011); location unspecified. **El-Sayed (2013); location unspecified. ***A.-F.M. El-Sayed (2013), personal contact with a farm owner. ****Radwan and Leschen (2011). ¹NA= not available.

Eissa and El-Tokhy (2011) evaluated the economic performance of two fish farms: one coastal farm in Shata coastal area (Domiati) and the other in the desert area (Giza). The results indicated that the internal rate of return of both farms was similar (34 percent for the coastal farm and 35 percent for the desert farm), but the recovery period was shorter and the profitability index was higher in the desert farm (1.35) than in the coastal farm (1.27). However, a main limitation for desert farms is the excessive use of water. The study suggested that reuse of farm water in irrigating land crops could increase the profitability and sustainability of aquaculture in the desert.

In a recent study on production functions for pond-raised Nile tilapia (*Oreochromis niloticus*) in Fayyum governorate, Hebicha, El-Naggar and Nasr-Allah (2013) found that farmers lack the necessary knowledge about farm management, including water quality, stocking density, stocking size and marketing. They generally use stocking rates much higher than the optimal by 36 percent to 115 percent and at the same time use insufficient feed by 8 percent to 22 percent. The results also showed that a change in the tilapia selling price has greater effect on profits, yield, stocking and feeding rates than a proportional change in feed price. Profits, feeding and stocking rates are more sensitive than yield to changes in selling price, while feeding rate is more sensitive than the stocking rate, yield and profits to changes in feed price. However, the results of this particular study should not be generalized because the study assumes an identical production function for all farmers, whereas different farmers may adopt different practices and technologies and face different technical, financial and legal constraints and hence have different production functions.

4.3 Profitability of integrated tilapia aquaculture

Fish culture (and tilapia culture in particular) in rice fields has great potential in Egypt, as noted earlier. This practice can lead to substantial value addition in terms of extra income generation, improvement in rice crop production and part-time “own enterprise” employment, particularly during harvesting and selling of products. It also plays a significant role in the alleviation of poverty and malnutrition of rural households, especially for nutritionally vulnerable groups, through providing good quality animal protein at low prices.

Fish culture in rice fields has received considerable attention in recent years as a means of rural development, food security and poverty alleviation in developing countries. Raising fish in rice fields has many advantages (El-Sayed, 2006), including the use of fish and feed wastes as fertilizer for rice, the use of fish to control pests (such as leafhoppers, stem borers and aphids) and weeds (consumed by herbivorous fishes) in rice fields, increases the rice yields, increases the revenue from both rice and fish production, and provides an additional source of protein (especially in rural areas).

The profitability of raising tilapia in rice fields has been investigated by Salama (2009) in a number of major rice farming governorates (Dakahlia, Domiat, Fayyum, Kafr El-Shaikh and Sharkia). The findings, which are summarized in Table 5, indicate that an increase between 18 and 40 percent in the net profits can be achieved when tilapia are farmed in rice fields, depending on fish stocking density and fingerling size, rice strain and farming system applied. The best value addition was obtained in Domiat governorate, where a 40 percent increase in net profit was achieved when tilapia were raised in rice fields for 90 days. In Kafr El-Shaikh governorate, a 32 percent increase in net profit was gained when monosex Nile tilapia fingerlings (2–4 grams) were stocked in the rice field at 2 400 fish/ha with 120 ducks/ha.

Table 5: Economic performance of integrated tilapia culture

Parameter	Dakahlia (2003)		Kafr El-Shaikh (2005)*		Fayyum (2006)		Domiat (2006)		Sharkia (2008)	
	Rice alone	Rice and fish	Rice alone	Rice, fish and duck	Rice alone	Rice and fish	Rice alone	Rice and fish	Rice alone	Rice and fish
Tilapia stocking density/ha		1 440–1 680		2 400		2 640 + 960 carp		3 360		2 400
Fish size (g/fish)		25		2–4		10		10		12
No. of ducks/ha	–	–	–	120						
Culture period (days)		86	–	79		58–68		90		97
Total production:										
Rice crop (tonnes/ha)	9.6	10.8	11.52	13.2	9.6	10.8	7.2	8.4	8.64	9.6
Rice straw (tonnes/ha)			7.2	7.2	7.2	7.4	4.8	6.0	7.2	7.2
Tilapia (kg/ha)	–	202		84		180		216		96
Other fish**						132		132		
Average duck weight (kg)	–	–	–	2.5						
Total production costs*** (US\$)****	934	1 154	790	1 106	788	1 019	661	823.3	789	858
Production value (US\$/ha):										
Rice crop	2 444	2 749	2 804.6	3 214.3	2 337.4	2 629.6	1 753	2 045.2	2 331	2 590
Rice straw	–	–	42	42	42	42	41.7	41.7	45	45
Tilapia	–	222	–	104.6		219		225.4		91
Other fish	–	–	–			142		100.2		
Duck	–	–	–	469.6						
Total value (US\$/ha)	2 444	2 971	2 846.6	3 830.5	2 379.4	3 032.6	1 794.7	2 412.5	2 376	2 726
Net profit (US\$/ha)	1 510	1 817	2 056.6	2 724.5	1 591.4	2 013.6	1 133.7	1 589.2	1 587	1 868
Profit increase due to integration of fish culture by amount (US\$/ha) and percentage	307 (20%)		668 (32%)		422 (27%)		456 (40%)		281 (18%)	

Notes: Values extracted from Salama (2009).

*Monosex Nile tilapia. **Catfish and common carp. ***Production costs included the costs of rice seeds, water, energy, fuel, fertilizer, labour, fish seeds and fish feeds.

****US\$1 = 5.5 LE in 2003; 5.75 LE in 2005; 5.75 LE in 2006; and 5.3 LE in 2008.

Van der Heijden (2012) evaluated water use and water quality changes in integrated tilapia farming systems under Egyptian conditions in four commercial farms in the governorates of Behaira, North Sinai and Sharkia. The water in the two farms came from wells and was used for intensive tilapia farming in concrete tanks. The water drained from the fish tanks was then used to irrigate fruit trees, vegetables, flowers and alfalfa. Fish was the main source of income for these farms. The other two farms used freshwater from nearby irrigation canals. These farms had constructed water reservoirs to irrigate fruit trees and vegetables when water supply from the irrigation canal was insufficient. Tilapia was stocked in the reservoirs as an additional crop to obtain extra income. Crops and fruits were the main source of revenue for these two farms with fish being a secondary crop.

These results show that it is possible to increase water use efficiency through integrating agriculture and aquaculture. This practice can also lead to a significant reduction in the use of chemical fertilizers and in turn can increase farm incomes through increasing productivity per unit of water. However, the volume of water required by the crops and the timing of irrigation should be matched with the volume and timing of effluent drainage from the fish culture facilities (Van der Heijden, 2012).

4.4 Financial services in the aquaculture sector

While aquaculture involves various risks (Pillay, 1994), an insurance system is currently not available for fish farmers in Egypt. Yet the availability of aquaculture insurance would significantly promote the development of this sector by ensuring more stable incomes and increasing incentives in aquaculture investment. Aquaculture insurance would also improve the access to formal credit by reducing the risk of loan default for financial institutions (Naziri, 2011).

The lack of access to credit has been one of the major constraints to the development of aquaculture for many years (El-Naggar, Nasr-Alla and Kareem, 2008). Zwirin (2002) and El-Gayar (2003) reported that inequity in access to capital is a serious problem facing the sustainable long-term development of the aquaculture sector.

According to Naziri (2011), both state-owned banks and private banks are reluctant to finance aquaculture enterprises for various reasons, including: (i) aquaculture is generally perceived as a risky business; (ii) banks are unfamiliar with the sector and are not prepared to carry out proper risk assessments; (iii) Egypt's banks do not want to be bothered with small- and medium-scale fish farmers who generally seek small loans; (iv) small- and medium-scale enterprises in the aquaculture sector generally lack landownership, which is usually required by banks for extending loans; (v) banks require accurate feasibility studies or business plans for the investment in order to verify its ability to achieve enough profit for repayment; (vi) most of the small-scale fish farmers who seek credit are illiterate and often do not know how to present their projects to financial institutions and have little chance to fulfil the bank's requirements; and (vii) most small- and medium-scale enterprises are not able to provide collateral (fixed assets, movable assets, savings certificate, etc.) required by banks for loan guarantees. Accordingly, only large aquaculture enterprises that can meet these requirements and fulfil the required guarantee are able to obtain credit from the formal financial sector at a commercial interest rate between 12 and 14 percent (Naziri, 2011).

On the other hand, many small-scale fish farmers receive inputs from large enterprises (e.g. feed mills, hatcheries, veterinary services and traders) on a credit basis, such as purchasing feed and seed on credit. In such cases, the cost of these inputs can be paid after fish harvesting and selling. The input suppliers generally do not charge any interest for delayed payment of the input. However, the use of this type of credit has its own drawbacks (El-Sayed, 2007; Naziri, 2011), including: (i) the prices of inputs purchased on credit are sometimes higher than market prices; (ii) in many cases, farmers receive poor quality input (especially feeds and seeds) but cannot complain or object; and (iii) farmers are often forced to harvest and sell their fish during the fattening season when the market prices are the lowest because the supplier often requires payment as soon as possible regardless of the best time to market the fish.

In some cases, traders offer farmers credit for the purchase of their fish after harvest. The contract between the farmer and the trader often entails the sale of the fish at an agreed price. The price, however, is usually lower than the market price at harvest time, which leaves the farmer at a disadvantage situation and may cause a significant economic loss.

5. SOCIO-ECONOMIC CONTRIBUTIONS OF TILAPIA AQUACULTURE IN EGYPT

5.1 Creating employment

In Behaira governorate, the majority of fish farmers (94 percent) fall within the age range of 21–60 years of age, with an average age of 43 years (El-Naggar, Nasr-Alla and Kareem, 2008). Most of these fish farmers are married. This would enhance the dependence on family labour in fish farming, leading to a reduction of hired labour.

The number of people engaged in aquaculture in general, and in tilapia culture in particular, is substantial. Macfadyen *et al.* (2011) estimated that the full-time equivalent (FTE) employment per 100 tonnes of fish produced from fish ponds is 8.3. If the number of traders, wholesalers and retailers is added, the number increases to 13.8 jobs per 100 tonnes. Assuming the same employment-production relationship for tilapia farming, then the FTE employment directly generated by tilapia farming (ponds, cages, tanks and rice fields) would be estimated at 50 681 farmers and the FTE employment in the tilapia value chain would be 84 265.

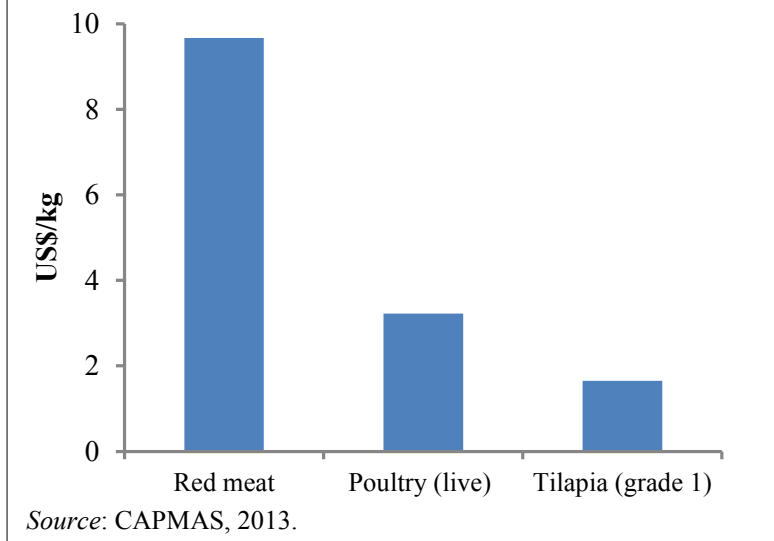
The number of full-time people working in fish feed production in state-owned feed mills amounts to 590 people, and the number of part-time jobs is about 4 500. In addition, there are about 1 000–1 500 full-time jobs in fish feed production within the private sector (A.-F.M. El-Sayed, personal survey, 2013). Many other people are involved in trading and handling of other aquaculture inputs (such as fertilizer, feed ingredients, premixes, drugs, plastic sheets, aerators, fuel, ice-making and selling, fish boxes and fish feed bags).

Family “employment” is also substantial in the aquaculture sector. For example, Yousef (2009) reported that a fish farmer in Kafr El-Shaikh, where 50 percent of total aquaculture production is produced, is assisted by 3.48 family members on average.

5.2 Improving livelihoods

Commercial aquaculture can greatly improve the livelihoods of the poor, mainly by generating employment opportunities through the value chain and through the provision of a cheap, high-quality animal protein source. It has been reported that the establishment of commercial aquaculture is generally accompanied with a relative decline in the price of fish in markets, where low-income consumers particularly benefit (Dey *et al.*, 2005). This has been the case in Egypt, where aquaculture production increased from 139 389 tonnes in 1998 to 986 820 tonnes in 2011, leading to more stabilization of the source of fish and making it the most affordable source of animal protein for the poor and for Egyptian society as a whole (Little *et al.*, 2012) (Figure 10). Because tilapia represented 62 percent of the total aquaculture production in Egypt in 2011, it is assumed that 620 grams from each kilogram of farmed fish consumed came from farmed tilapia.

Figure 10: Retail prices of major animal protein sources in Egypt in 2012



5.3 Improving per capita fish consumption

It is clear from the above discussion that tilapia culture has made fish the most affordable source of animal protein, especially for the poor. As a result, the annual per capita consumption of fish increased from 9.5 kg in 1995 to 19.1 kg in 2011 (Figure 11), representing 50 percent of total animal protein consumption, while the consumption of poultry and red meat contributed 27 and 23 percent, respectively (Figure 12). Tilapia accounted for nearly half of the total fish consumption in 2011, indicating

that the fish is probably the most important single animal protein source for Egyptians. It should be emphasized that almost all tilapia produced in Egypt is consumed domestically. Only occasionally a few tonnes are exported to the Gulf region.

Figure 11: Self-sufficiency and per capita consumption of fish products in Egypt

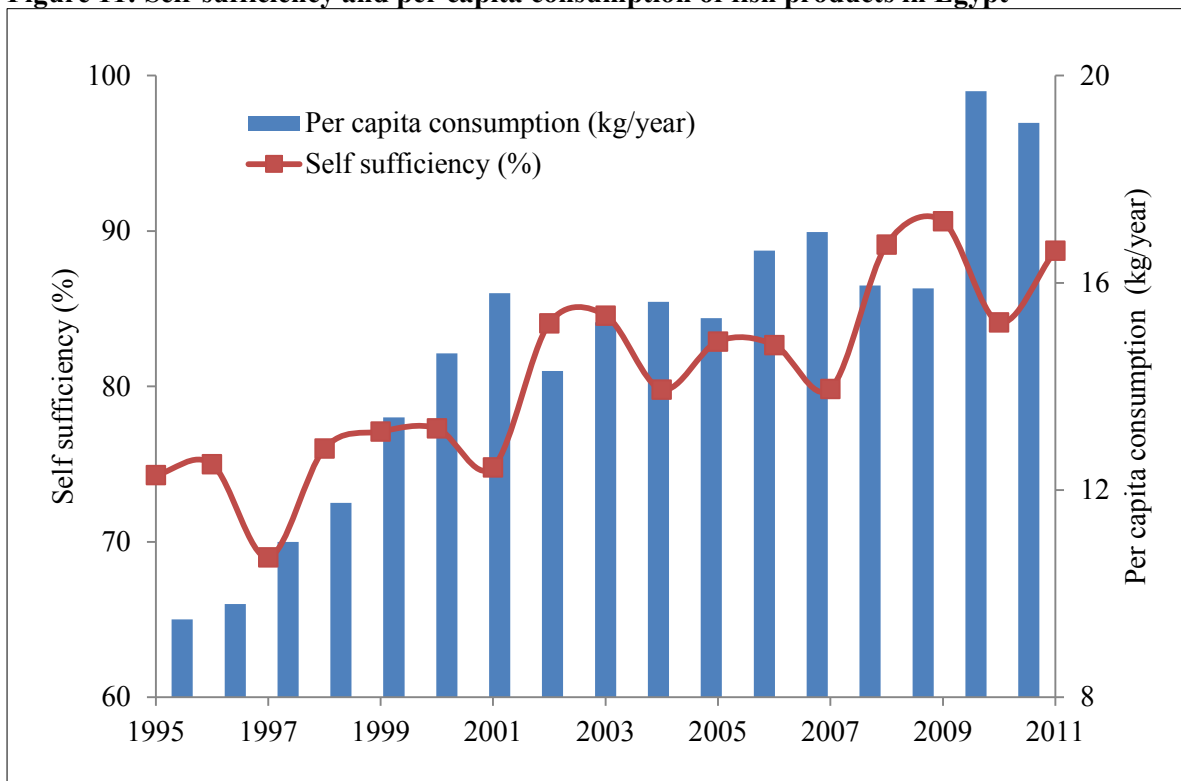
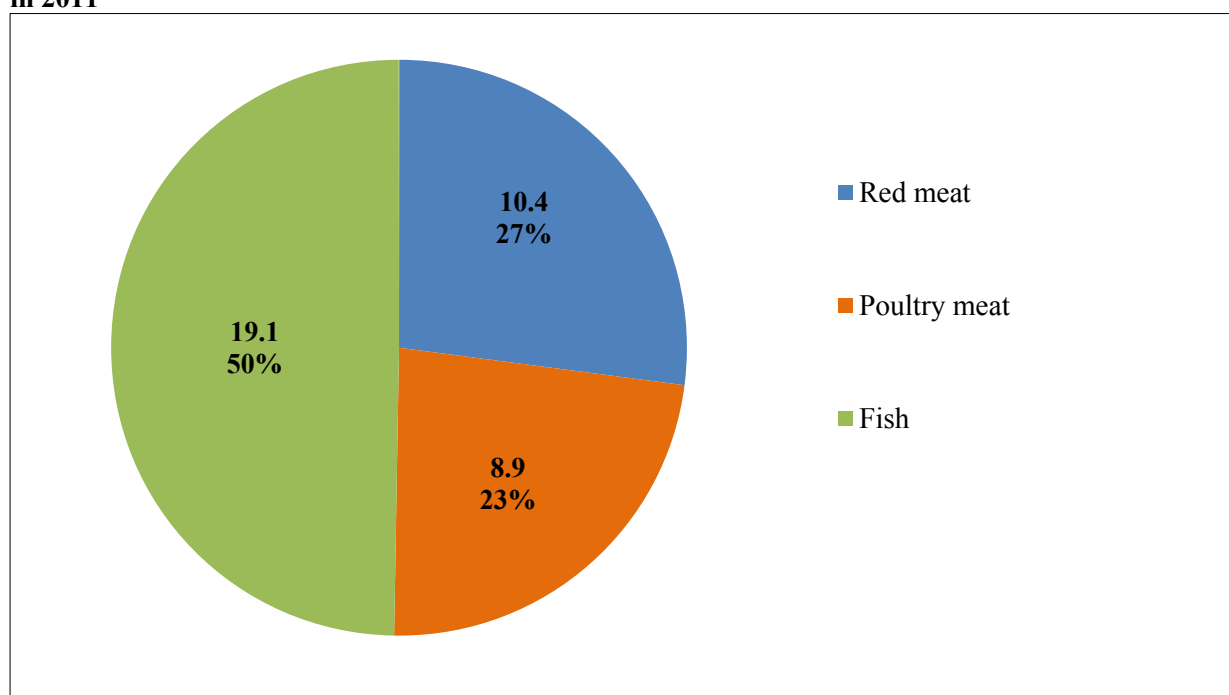


Figure 12: Per capita consumption (kg/capita per year) of major animal protein sources in Egypt in 2011



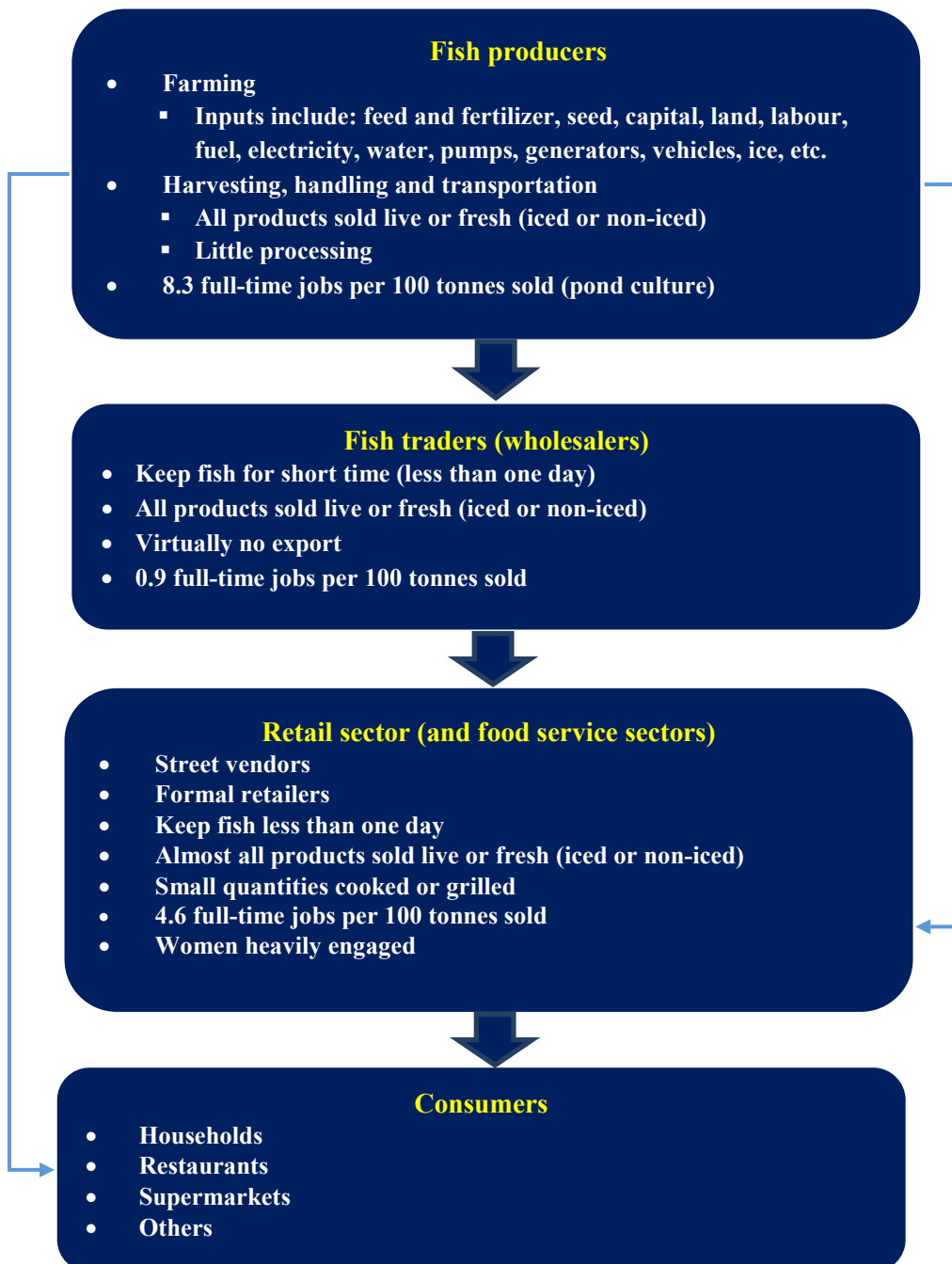
Source: Red meat and poultry meat, CAPMAS, 2013; fish, GAFRD, 2012.

Integration of tilapia culture with land crops such as rice leads to substantial socio-economic benefits. For example, an increase between 18 and 40 percent in net profits can be achieved when tilapia are farmed in rice fields in an integrated way (Salama, 2009). This practice also plays a significant role in the alleviation of poverty and malnutrition of rural households, especially for nutritionally vulnerable groups, through providing good quality animal protein at low prices in addition to sustainable rice (and other crops) supply.

6. FARMED TILAPIA VALUE CHAIN IN EGYPT

The domestic value chain of farmed fish (and wild fish as well) is simple and short, but rather efficient. It takes only one to two days from harvest to the final consumer, with low post-harvest loss (Macfadyen *et al.*, 2011; Macfadyen, Nasr-Allah and Dickson, 2012). The domestic distribution system is also quite efficient, mainly because most production centres are located near major cities and populated areas (Rothuis *et al.*, 2013). The value chain of farmed tilapia in Egypt includes only three main categories before reaching the final consumer – fish producers (input production, farming, harvesting, handling and transportation), fish traders (wholesalers), and retailers (Figure 13).

Figure 13: Value chain of farmed tilapia in Egypt



Source: Macfadyen *et al.* (2011) with modification.

6.1 Fish harvesting, handling and transport

The harvesting of tilapia begins as soon as the fish reach marketable size (October–December). Most small-scale farmers harvest their ponds by themselves. Large farmers usually depend on seasonal labourers for harvesting tilapia crops. Harvested tilapia are cleaned, sorted, weighed, stocked in plastic boxes with or without ice depending on the distance to the market and loaded on trucks to the markets (Plate 11).



6.2 Wholesale markets

The wholesale market in each governorate or major city is controlled by a few large traders (wholesalers) who determine the market prices mainly according to the supply and demand (Macfadyen *et al.*, 2011). The majority of fish farmers sell their harvest to wholesalers. However, some farmers, especially those producing small amounts, sell their fish to retailers and sometimes directly to consumers (Macfadyen *et al.*, 2011). Farmers usually have agreements with wholesalers who purchase their harvest directly at the farmgate.

In many cases, a wholesaler finances the production costs and buys the fish harvest at a price agreed upon in advance, which is generally lower than the prevailing market price. In each of the major cities (particularly the capitals of governorates), there is a number of wholesale vegetable and fruit markets (such as El-Obour Market near Cairo, and Hadra, Zananiri and Baccus markets in Alexandria) where fish producers generally bring and sell their products through auctioning or directly to consumers.

Specialized fish markets are also distributed in the major coastal cities and towns close to fish production areas (such as Anfoushy and Abu Quir fish markets in Alexandria, Fish Stock Exchange in Kafr El-Shaikh, Plate 12, and Ezbet Al Borg in Domiat), where fish auctions and marketing take place. Traders and wholesalers usually employ a small amount of labour, primarily for fish handling, loading, unloading and transportation.

Plate 12
Tilapia wholesale market at the Fish Stock Exchange in Kafr El-Shaikh



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

El-Obour wholesale market is the largest and most important fish market in Egypt (Feidi, 2004; Norman-López and Bjørndal, 2009). The market supplies whole fresh tilapia and frozen tilapia fillets. The majority of Egyptian tilapia is sold whole fresh, as this is the preferred product form for most Egyptians. Farmed and wild caught whole fresh tilapia are generally marketed in El-Obour market in three grades according to quality and size: Grade 1 (375–600 grams); Grade 2 (250–375 grams); and Grade 3 (100–250 grams) (Macfadyen, Nasr-Allah and Dickson, 2012). However, these grades may differ from one place to the other and from one selling segment to the other. For example, Feidi (2004) reported that the average fish weight in Grade 1 tilapia is 200–1 000 g/fish (1–5 fish/kg). Grade 4 tilapia (exclusively wild caught fish) weighing less than 100 g/fish is also commonly marketed, particularly in rural areas and among lower-income classes in urban areas. Frozen tilapia fillets are supplied as one single grade mostly to restaurants and hotels catering to high-income Egyptians and tourists.

The wholesale prices of Grade 1 tilapia increased modestly in the period 2000–2010, ranging from LE 7.7 to LE 9.0 per kg. Yet the price increased significantly from 2011 to 2013 to LE 12.7 per kg (Table 6). Similar trends have been observed in the prices of Grade 2 and Grade 3 tilapia. However, when the inflation rate (about 7 percent) during these periods is considered, the prices have decreased in real terms (Rothuis *et al.*, 2013). According to Macfadyen *et al.* (2011), the real price declined by 45.9 percent over the period 2000–2010 for catfish, 37.7 percent for tilapia, and 31 percent for mullet. Although the lower prices may be good for consumers, they present a serious challenge for the financial performance of the producers.

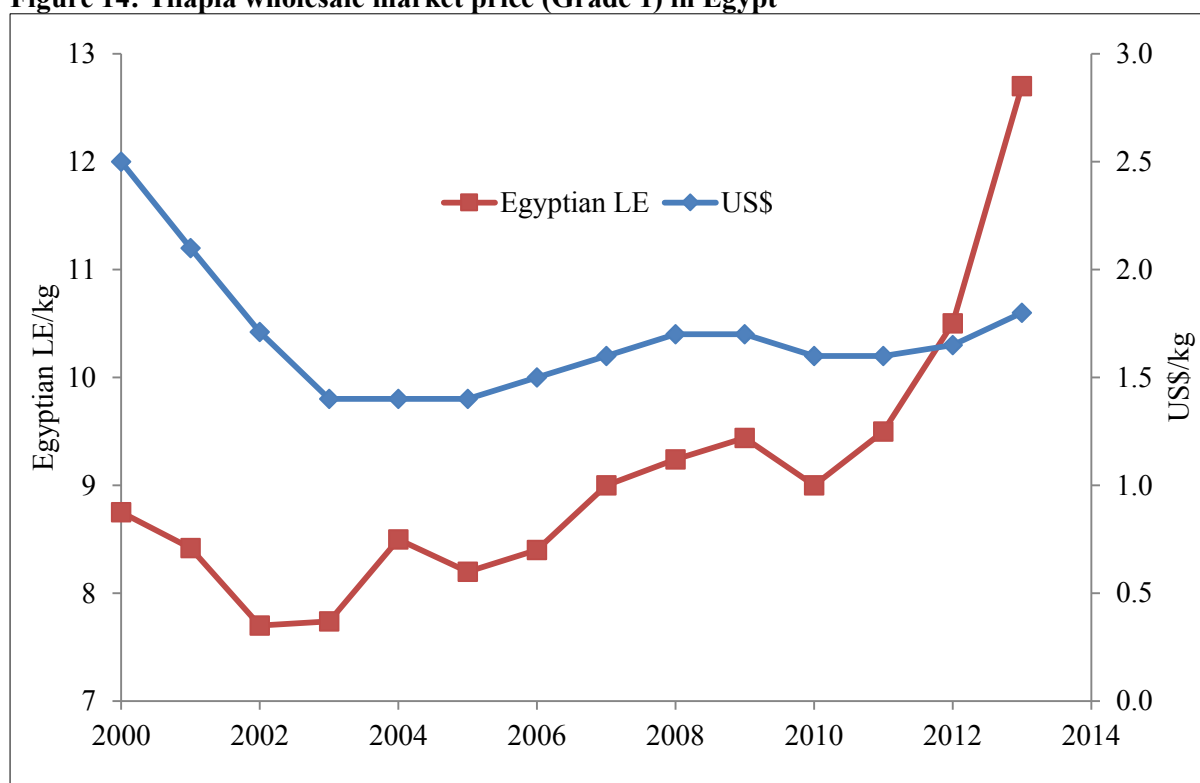
Table 6: Tilapia wholesale prices in Egypt

Tilapia	Currency	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Grade 1*	US\$	1.40	1.40	1.50	1.50	1.70	1.70	1.60	1.60	1.65	1.92
	LE	8.50	8.20	8.60	8.30	9.24	9.44	9.00	9.50	10.50	12.70
Grade 2**	US\$	0.95	1.00	1.10	1.20	1.30	1.40	1.20	1.40	1.33	1.50
	LE	5.90	5.70	6.30	6.60	7.10	7.30	7.22	8.10	8.50	9.90
Grade 3***	US\$	0.55	0.57	0.60	0.70	0.94	1.10	0.83	0.70	0.92	1.04
	LE	3.40	3.25	3.45	3.85	5.10	5.40	4.80	4.10	5.80	7.00
Tilapia fillet	US\$	2.60	2.70	3.50	4.00	5.10	5.10	6.00	5.90	6.00	6.50

Source: GAFRD, 2000–2013. Value converted to United States dollars based on the exchange rate of the year. *1–5 fish/kg (Feidi, 2004); 1–3 fish/kg (Macfadyen, Nasr-Allah and Dickson, 2012). **5–10 fish/kg (Macfadyen, Nasr-Allah and Dickson, 2012). *** >10 fish/kg (El-Sayed, personal survey).

Tilapia prices in United States dollars have also fallen in the period 2000–2013 (Figure 14), presumably due to the decrease in the value of the Egyptian pound against the United States dollar (e.g. US\$1 = 3.75 LE in 2000 and 6.36 LE in 2012).

Figure 14: Tilapia wholesale market price (Grade 1) in Egypt



Sources: GAFRD, 2000–2011; El-Obour Market, 2013.

It should be mentioned, however, that tilapia (and other fish) prices exhibit sharp daily and seasonal fluctuations depending primarily on changes in the demand and supply on particular days or between different months. Generally, wholesale prices decrease during the harvest season (September through early December) when the supply is high (Macfadyen *et al.*, 2011). The price of tilapia depends also on market distance. The farther the market distance, the higher the transport costs and hence marketing costs, which in turn increase the price of tilapia. Other factors that directly or indirectly affect tilapia prices include biological environment, farming technology applied, policy and institutional environment, and production costs (harvesting, handling, transport, etc.) (Ahmed *et al.*, 2012). The fluctuation in fish price poses particular risks to fish farmers because they incur costs for long periods before the fish is sold. For wholesalers and retailers, price fluctuations represent less risk as the reduction in price can be passed back down the value chain to fish farmers.

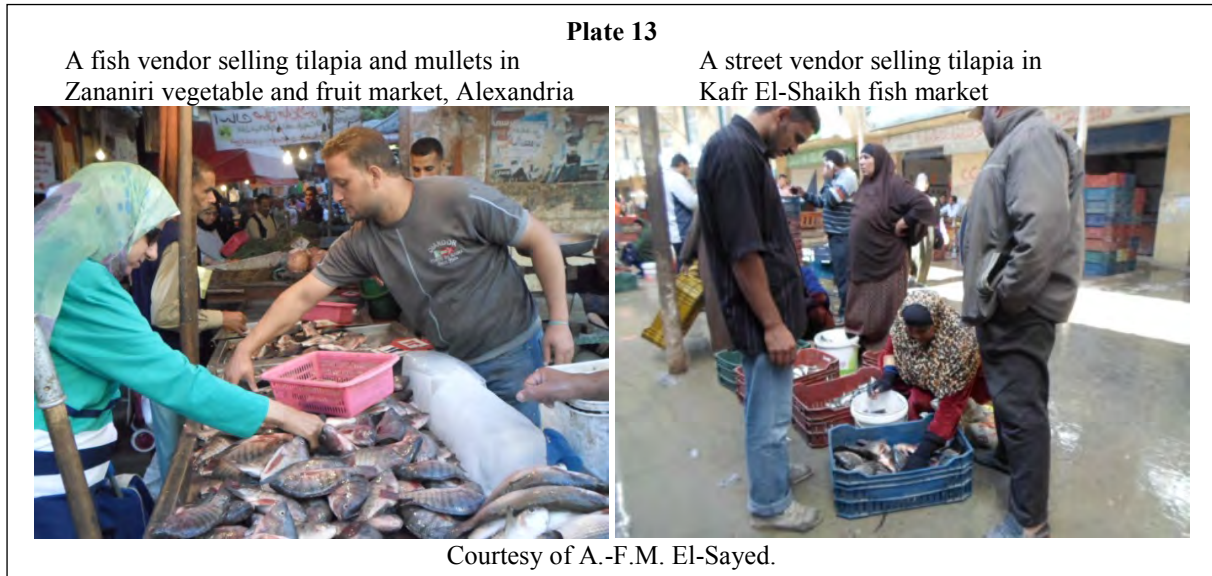
6.3 Retail markets

There are two main types of farmed fish retailers in Egypt (Macfadyen *et al.*, 2011):

- Street vendors who purchase fish from wholesale markets or traders and retail the fish by the roadside (with simple facilities such as a shelter, table and/or box) or inside vegetable and fruit markets. This category has minimal employment (Plate 13).
- Formal retailers are registered retail shops usually equipped with facilities such as refrigerators and/or freezers for storing fish that cannot be sold in time. These retailers often employ labour to clean, prepare and sell fish. Many of these retailers provide fish cooking (e.g. grilling and frying) and delivery service. The service is widespread throughout the country, especially among working households who return home late from work and do not have time for fish cleaning and cooking. The fixed and operational costs of formal retailers

are usually higher than street vendors. More employment is available in formal retail businesses.

A small volume of tilapia is marketed through multiple retailers (e.g. hypermarkets or supermarkets) and the food service sector (e.g. fish restaurants and fish fryers or grillers).



The majority of Egyptian tilapia consumers prefer whole fresh fish to processed fish (Feidi, 2004, 2010). Almost all tilapia are sold fresh, whole and in unprocessed form with little value addition. There is a growing preference for live tilapia, especially wild fish, in many areas of the country. Live tilapia are usually transported by traders in drums or tanks with oxygen to wholesalers or retailers in places like Fayyum governorate. In Alexandria and many Nile Valley governorates, live tilapia are held in pens or cages and sold as “wild fish”. In other governorates of the Delta, live fish may be held in irrigation channels and sold as wild fish.

Farmed and wild caught tilapia are marketed together in the retail market. There is a common (mis)perception among consumers about the quality of farmed tilapia. Many consumers believe that farmed fish, including tilapia, are inferior in quality to wild caught fish and also claim that fish feeds contain dead animals, animal wastes (feather, guts, blood, etc.) and hormones (Feidi, 2010). However, consumers are unable to differentiate between farmed and wild caught tilapia. There are currently no regulations requiring domestic fish products to reveal their origins including whether they are farmed or wild caught.

Egyptian women are heavily engaged in road-side fish retailing, especially in rural and marginalized areas (Plate 14). Women fish vendors are usually poor and work in fish retail because their husbands are fishers, or they are widowed or divorced, or their husbands are unable to hold full-time employment (Hussein *et al.*, 2012). They work under poor and unhygienic conditions. Most women retailers purchase fish from wholesalers in the fish market, while some of them also buy fish from a trader. Typically, women retailers purchase small amounts of fish on a daily basis (about 25–50 kg) in order to sell all of it during the same day because they usually do not have the appropriate means of handling and storage (containers, refrigerator or freezer). Therefore, women retailers may drop fish prices at the end of the day in order to sell the entire product and be able to pay the wholesaler before purchasing the next batch of fish (Hussein *et al.*, 2012).

According to WorldFish (2011) and Hussein *et al.* (2012), fish market promotional strategies should give special attention to women street vendors because of the important role they play in generating women’s employment and in the provision of affordable fish to low-income consumers, particularly

in rural and remote areas. Attention should also be paid to sellers of live tilapia because of the value addition they generate and the quality of the fish they produce. Multiple retailers should also be highlighted because the expected growth in this segment in the coming years has potential to provide an outlet for value-added products such as fish fillets and nuggets and hence create job opportunities for both men and women.



6.4 International fish trade

In 2011, Egypt imported 182 000 tonnes of fish with a total value of about US\$544 million (GAFRD, 2012). The major fish suppliers to Egypt include the Netherlands, Japan, Viet Nam, Norway, and to a lesser extent, Yemen, Spain, China and Pakistan (Rothuis *et al.*, 2013). A large amount of canned tuna (from Thailand, Japan and Singapore) and sardines (mainly from Morocco and Thailand) are also imported annually.

Egypt's export of fish products is almost negligible. In 2011, the amount of fish exported was only 9 490 tonnes, estimated at about US\$24.5 million (GAFRD, 2012). The amount represented only 0.7 percent of total production. The fish exported is generally high-value marine fish such as seabream and seabass (from Bardaweel saline lagoon), European eel and mullet caviar. In addition, some small amounts of tilapia and salted fish are exported to some Arab countries, especially to the Gulf States. There is a small but rapidly growing export market for whole fresh tilapia to some Middle East countries, especially in the Gulf region, mainly because of the high buying power of the large Egyptian communities living in these countries.

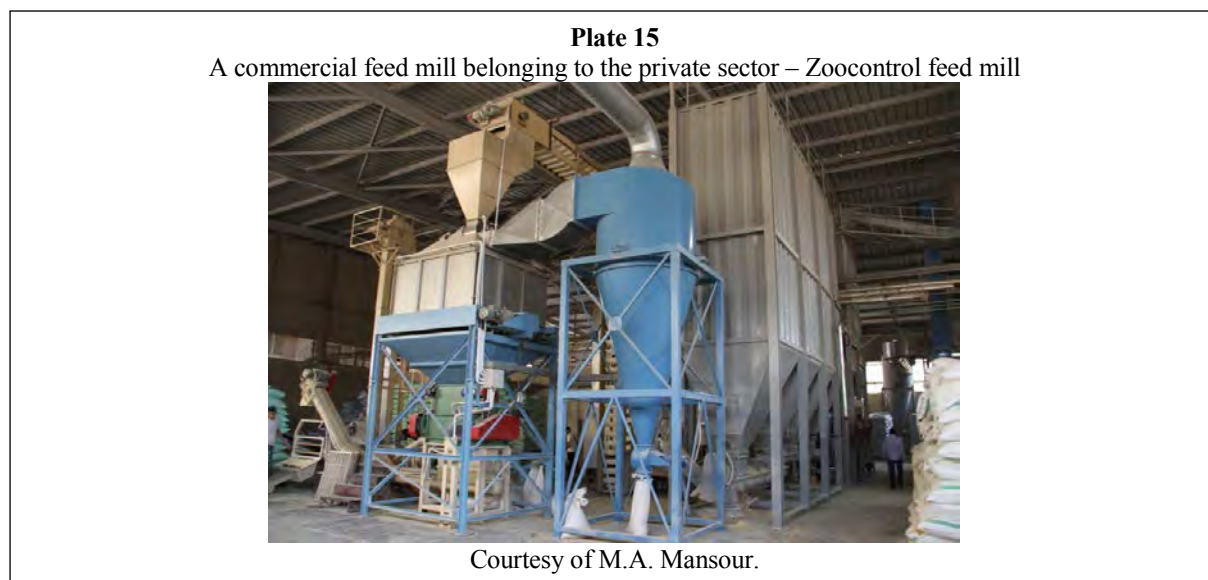
7. FISH FEED INDUSTRY IN EGYPT

7.1 On-farm tilapia feed manufacturing

Farm-made fish feeds virtually do not exist in Egypt. Only very few farmers in remote rural areas who produce fish primarily for family subsistence may make their own tilapia feeds. These farmers generally depend on local feed ingredients, including agricultural by-products (wheat bran, corn bran, rice bran), animal by-products (blood meal, offal, poultry by-product, etc.) and kitchen leftovers. Farmers generally do not extrude the diets; instead, they feed moist feed balls to the fish. Some small-scale farmers feed dry feed mixture either by filling the feed in jute bags and suspending them in the water column or by broadcasting the feed mixture over the water surface. Some cage farmers in the Rosetta branch of the Nile River near the river mouth do not use processed feed, but feed their caged tilapia and mullets on feed ingredients such as corn flour, wheat bran, rice bran, bakery wastes and macaroni industry wastes.

7.2 Commercial fish feed production

Fish feeds in Egypt are produced both by state-owned companies and the private sector. In 2009, there were about 31 fish feed mills, 11 belonging to the public sector and 20 owned by private producers, with a production capacity of about 420 000 tonnes/year (El-Sayed, 2013). About 80 percent of fish feed was produced by the private sector (Plate 15), while the remaining 20 percent was produced by state-owned mills.



In a recent survey, El-Sayed (2014) analysed the value chain of the aquafeed industry in Egypt. The results indicated that there are 9 state-owned fish feed mills and over 50 registered private feed mills distributed throughout the country, particularly in the areas of, or close to, aquaculture production. The production capacities of these mills range from 5 000 to over 30 000 tonnes per year per mill (average about 14 000 tonnes per year per mill).

No accurate official data are available on the current fish feed production. However, according to the findings of the survey, El-Sayed (2014) suggested that fish feed production ranged from 900 000 to 1 000 000 tonnes per year.

Feed mills produce both compressed (sinking) and extruded (floating) pellets for various freshwater, brackish water and marine fish species. Sinking pellets represent about 75–80 percent of the total annual fish feed produced. Most of the feeds produced by the private sector contain 25 percent CP, while others may contain 30, 32 and 35 percent CP and are generally produced upon the farmers' request. In addition, a few tonnes of feed containing over 40 percent CP are produced upon the request of farmers and used for larval feeding or marine fish feeding.

In addition, there are about 50 small-scale pelletizing units, each with a production capacity of 3 000–4 000 tonnes of fish feed per year, with total annual production from 120 000 to 240 000 tonnes (El-Naggar, Nasr-Alla and Al-Kenawy, 2011). The majority of these pelletizing units are not registered and therefore their production is generally not recorded or reported. However, current estimates suggest that the number of non-registered fish feed pelletizers has dramatically increased during the past few years to over 200 units.³ Most of the milling units are locally made, use simple technologies, and are not equipped with air driers.

According to the author's personal survey in 2013, many farmers buy their own ingredients, prepare their feed formulae, and rent the feed mill to manufacture the feed. These farmers generally do not

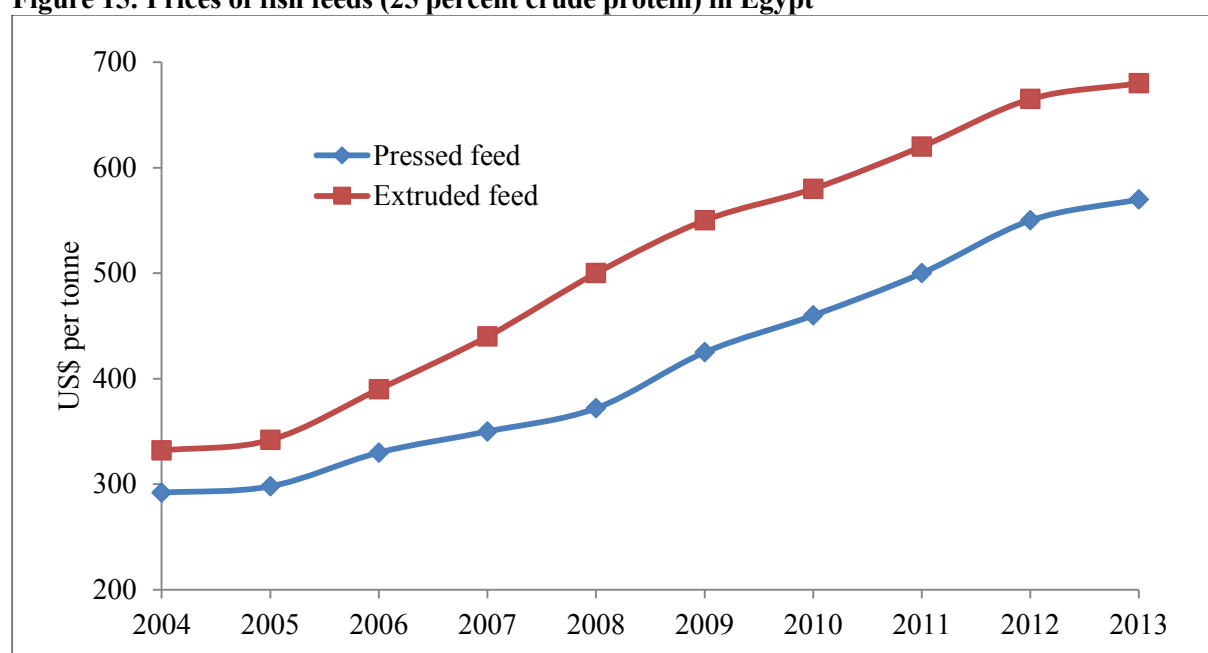
³ Information from personal communication with S. Desouky (a fish mill owner in Manzala Dakahlia) in 2013.

report the amount of feed they produce. This approach leads to a substantial reduction in feed costs for the farmers.

It is clear from the above discussion that the amount of fish feed produced in Egypt may be substantially higher than the reported/estimated volumes. Accordingly, it is safe to suggest that the total amount of fish feed produced by the private and public sectors (both reported and unreported) ranges between 800 000 and 1 000 000 tonnes per year.

The prices of compressed tilapia feeds have more than doubled during the past decade, increasing from a little less than US\$260/tonne (25 percent CP) in 2003 to US\$520/tonne for the public sector and US\$570/tonne for the private sector in 2013. Similarly, the price of extruded feeds increased from US\$300/tonne in 2003 to about US\$680/tonne (25 percent CP) and US\$720/tonne (30 percent CP) in 2013. The price trends of pressed and extruded feeds in Egypt from 2004 to 2013 are illustrated in Figure 15.

Figure 15: Prices of fish feeds (25 percent crude protein) in Egypt



Source: El-Sayed, 2007; A.-F.M. El-Sayed (personal survey, 2013).

The increasing prices of both compressed and extruded tilapia feeds have been attributed primarily to the sharp increase in the prices of feed ingredients, especially imported ingredients such as fishmeal, soybean meal, corn, wheat bran and oils, in recent years. In addition, the increase in prices for extruded feeds is also related to high investment costs associated with the installation and operation of specialized extrusion facilities.

Most of the commercial fish feed produced in the country is packed in 25-kg polypropylene bags. The bags are closed mechanically either with a string or heat sealed (Plate 16). Produced feeds are generally stored for relatively short periods (maximum of 1–2 weeks) in shaded, well-aerated stores. Some factories, however, lack appropriate storage facilities for ingredients and finished feeds.

7.3 Tilapia feed industry

Most of the fish feed produced in Egypt is consumed by tilapia. Tilapia feeds are produced primarily in the form of conventional sinking pellets (Plate 17). Pellet sizes range between 2 mm and 5 mm. The feed is mostly used in semi-intensive culture systems – monoculture and polyculture systems with mullets and carps. The vast majority of tilapia farmers use 25 percent CP diets to feed their fish

throughout the whole production cycle. Only a few farmers use 30–35 percent protein diets during the early life stage and switch to 25 percent CP feed during the fattening stages. The formulation and proximate composition of typical 25 percent CP extruded and pressed feeds and 35 percent CP pressed feeds are presented in Table 7. Most of the aquafeed ingredients in the country are imported (El-Sayed, 2014).

Plate 16

Tilapia feed (25 percent crude protein) packed in 25-kg polypropylene bags



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

Plate 17

Compressed fish feed (*left*) and extruded fish feed (*right*) produced in Egypt



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

Extruded (floating) aquafeed technology was introduced in 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 significantly higher prices. Tilapia farmers may prefer this type of feed because it is better digested, converted and assimilated by the fish (El-Sayed, 2007). However, extruded feed is not always affordable by small-scale tilapia farmers.

The FCR for pelleted Nile tilapia feeds ranges from 1.5:1 to over 2:1, while the FCR associated with extruded feeds ranges from 1.1:1 to 1.5:1 depending on fish stocking size and culture system (Table 8). It is clear that the FCRs of larval and fingerling stages are higher than those of the grow-out and broodstock fish. This is primarily due to the fact that aquafeed manufacturers do not produce specialist larval and fingerling feeds (<1 mm). Instead, many of the farmers crush feeds formulated for grow-out (2–4 mm) into coarse powder for feeding to the fry and small fingerlings. This practice, however, leads to feed waste and results in a higher FCR in early growth stages.

Table 7: Formulation and proximate composition of commercial tilapia diets in Egypt

Feed composition	25 percent CP			35 percent CP
	Pressed (GAFRD)	Pressed (private sector)	Extruded (private sector)	Pressed (GAFRD)
Ingredients (percent)				
Soybean meal (44 percent CP)	37.5	33.0	19.0	40.0
Fishmeal (sardine, 60 percent CP)	6.0	6.0	9.0	22.0
Corn gluten	–	–	5.6	–
Yellow corn	22.5	32.0	30.0	12.0
Wheat bran	–	25.5	24.0	–
Rice bran	23.0		11.0	19.1
Oil	3.0	1.0	1.0	3.0
Calcium carbonate	4.7	2.0	–	3.1
Binder	2.5	–	–	–
Table salt	0.5	–	–	0.5
Vitamin mixture	0.3	0.5	0.4**	0.3
Antioxidant	0.025	–	–	0.025
Proximate composition (percent dry matter basis)				
Crude protein	25.0	25.0	25.0	35.0
Crude lipid*	8.8	6.6	7.5	8.4
Crude fibre*	5.7	6.4	5.4	6.3
Ash*	4.3	4.5	3.9	3.9
Nitrogen free extract*	56.2	57.5	58.2	46.4

Source: GAFRD, 2010; A.-F.M. El-Sayed, personal survey, 2012.

*Calculated by the author, based on the chemical composition of the ingredients. **Vitamin and mineral premix.

Table 8: Feed conversion ratio of Nile tilapia farming using 25 percent CP commercial feeds

Farming system	Larval feed*		Fingerling feed		Fattening feed	
	Pressed	Floating	Pressed	Floating	Pressed	Floating
Semi-intensive ponds	1.7–2.4	–	1.5–1.8	1.2–1.6	1.3–1.8	1.0–1.5
Intensive cage	–	–	1.6–2.0	1.2–1.5	1.3–1.7	1.0–1.4
Intensive ponds	1.5–2.4	1.4–2.3	1.5–1.8	1.0–1.5	1.2–1.5	1.0–1.3
Intensive tanks	1.5–2.0	1.5–2.0	1.5–1.9	1.0–1.4	1.3–1.5	1.0–1.1

Source: A.-F.M. El-Sayed (personal survey).

*Most of the farmers crush or grind feed pellets (2–4 mm) into coarse powder for feeding to fry or small fingerlings.

8. GOVERNANCE AND INSTITUTIONAL DIMENSION OF AQUACULTURE IN EGYPT

8.1 Aquaculture and fisheries legislation

Act No. 124/1983 is the main body of legislation regulating fisheries, fishing, aquatic life and aquaculture. The act contains a number of articles related to fisheries and the aquaculture industry. This law requires licensing of aquaculture activities by the General Authority for Fish Resources Development (GAFRD) under the following conditions: (i) land used should be in areas allocated for aquaculture and should not be suitable for agriculture; (ii) licence must indicate the quantity of water permitted for water use, its source, inlet size and the method of drainage; (iii) authorization for water

use must be obtained from the Ministry of Water Resources and Irrigation, in conformity with Law 48/1982; and (iv) a satisfactory environmental impact assessment (EIA) and the consequent approval from the Egyptian Environmental affairs Agency (EEAA).

Established by Presidential Decree No. 190/1983 under the Ministry of Agriculture, GAFRD is responsible for the administration and enforcement of Act No. 124/1983. Decree No. 465/1983 describes the powers and duties of GAFRD, including leasing all lands it controls within 200 metres of shorelines for aquaculture and fisheries activities. Decision No. 70/1986 specifies the lease of land allocated by GAFRD for the establishment of aquaculture facilities. Rental value should take into account the capacity of production, the location, and the availability of public utilities. Land is to be rented by public auction, unless: (i) rental is to government bodies, public companies or legal persons; (ii) projects are large, and have been proved economically feasible; (iii) where no bids are received, or bids are below the rentable value; and (iv) where existing leases are in operation at the introduction of the decision. The lease term is generally 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 a 15-day written notice.

Act No. 4/1994 prohibits the handling (including the collection, storage, transportation, treatment and disposal) of hazardous substances, including pesticides, fertilizers and pharmaceutical substances, without a permit from the competent authority. This act also specifies that an EIA of any commercial aquaculture activity should be conducted and be approved by the EEAA before authorization is provided by the GAFRD.

Decision No. 592/2012 (amendment of Decision No. 321/2012) regulates the collection and/or fishing of marine fish seeds for aquaculture needs. The new amendment has added more conditions and restrictions on fishing times, fishing authorization and supervision by GAFRD.

Decision No. 831/2013 specifies the renewal of the lease contracts for 25 years. The decision states that the lease contract for fish farms and fish hatcheries on state-owned lands is five years, and that it may be renewed for one or more terms for a maximum of 25 years upon the authorization of the authorized minister and the approval of GAFRD, in accordance with the following conditions and controls: (i) the contractor's commitment to vertical expansion in fish production using productive technology in the farm or hatchery, and to make the necessary infrastructure and development at one's own expense; (ii) GAFRD shall review the extent to which the application of technologies and contracting development has been fulfilled, after the termination of each term, as a condition to renew the contract for the following term; (iii) the rental value will increase by 5 percent of the contract value annually; (iv) the rental value for each term of the contract will be determined in accordance with the prevailing prices; and (v) GAFRD has the right to terminate the contract and relaunch the farm or fish hatchery if the contractor violates any of the obligations imposed on him or her for any term.

8.2 Access to land and water

According to Act No. 124/1983, only brackish water, marine water and infertile lands not suitable for agriculture can be used in aquaculture. Water supply for aquaculture is also restricted to brackish water from lakes and agriculture drains; the use of freshwater (irrigation water) is prohibited. Only hatcheries established by the government are exempted from this rule. By decree, the Ministry of Agriculture may specify areas for fish farming.

Nearly all aquaculture activities in Egypt are practised by the private sector, yet many fish farms, especially semi-intensive earthen ponds, are rented from the government through GAFRD. The extension of contract leases to 25 years will certainly provide stability to the business environment. Annual rental costs are generally low, ranging between US\$84 and US\$205 per hectare. Farms rented from other farmers or farm owners generally have infrastructure and are ready to use; therefore, rental

values are much higher (US\$740–US\$1 100 per hectare). Owned farms are rather expensive, as the cost for purchasing the land is high, ranging between US\$21 600 and US\$62 400 per hectare.

8.3 Fish movement

The collection and removal of fish fry from the sea, lakes or other waterbodies is prohibited without a permit issued by GAFRD, in accordance with Act No. 124/1983. Introducing non-indigenous species into the country is also prohibited without permission from GAFRD.

8.4 Environmental impact assessment

According to Act No. 4/1994 concerning the Egyptian Environmental Affairs Agency (EEAA), any new aquaculture establishments or projects, as well as expansion or renovation of existing establishments, must be subject to an EIA. The EIA should be submitted to GAFRD, which assesses it and sends a copy to the EEAA for review. Subsequently, GAFRD issues the licence. The act is implemented by Executive Regulation No. 338/1995, which identifies establishments and projects that must be subjected to an EIA. The EEAA has developed standard guidelines for the EIA in Egypt, which describes the procedures and steps required for preparing the assessment. The approach adopted in the guidelines depends on the classification of projects into three categories, reflecting increasing levels of an EIA according to the severity of possible environmental impacts: (i) “white” list projects with minor environmental impacts; (ii) “grey” list projects, which may have substantial impacts and may require a scoped EIA; and (iii) “black” list projects, which require a full-fledged EIA due to their potential severe impacts.

The guidelines include two screening forms: Form A for white list projects and Form B for grey list projects. For the grey list projects, the EEAA may require a scoped EIA – the scope is defined by the EEAA on the basis of information presented in Form B. Aquaculture projects belong to the grey list, which requires fish farmers to complete 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 full-fledged EIA study (FAO, 2013).

In practice, an EIA is rarely conducted for aquaculture activities *per se* (Nugent, 2009). Most aquaculture activities operating in freshwater or brackish-water environments continue to be regulated by the “old” legal frameworks of various sectoral ministries, coordinated to some extent by GAFRD, where the EIA is not required before a farmer begins aquaculture production. The only situation where the EIA is required is in the marine environment, where established rules for inland waters do not apply (Nugent, 2009).

8.5 Aquaculture research institutions

A number of universities and research institutes in Egypt, such as the Agricultural Research Centre (ARC), Ain Shams University, Al-Azhar University, Banha University, Cairo University, Damanhour University, Kafr El-Shaikh University, Minofia University, National Institute of Oceanography and Fisheries, National Research Center, Port Said University, Suez Canal University, Suez University, Alexandria University, University of Damietta, University of Mansoura, WorldFish, and Zagazig University, provide different academic degrees in fisheries and aquaculture (including diplomas, Bachelor of Science degrees, Master of Science degrees and PhD) and conduct research.

8.6 Fish farmers’ associations and non-governmental organizations

GAFRD (2010) reported that 11 aquaculture cooperative associations in Egypt, distributed in the major production governorates under the umbrella of the “General Union for Aquatic Resources”, had 1 726 members in total.

Active associations usually provide various services and assistance to (member) farmers, including:

- Buying good quality feed in bulk for the members, with price savings on bulk orders. Member farmers could pay for only 50 percent of the price and the rest is paid on credit or on monthly payments without increasing the price. This reduces the need for farmers to obtain credit from feed traders, reducing the risk to farmers of being provided with poor quality feed.
- Buying other production inputs such as seeds, additives, drugs, premixes, water-quality equipment in bulk and selling them to farmers at promotional prices (often on credit).
- Providing farmers with fish seed transportation at low costs.
- Training farmers in aquaculture activities, in cooperation with funding agents such as the Social Fund for Development, Egyptian Agribusiness Association, and training centres such as WorldFish.
- Helping in the establishment of new ponds and providing members with basic advice on farming practices.

However, many of the associations are inactive and provide little assistance to members. Therefore, the General Union for Aquatic Resources has started a rehabilitation programme for capacity building and institutional development of inactive associations. The programme started with five associations and includes training, providing aquaculture inputs, and promoting both fund training and management skills.

Some Egyptian non-governmental organizations (NGOs), such as the Egyptian Fish Council (EAGA), raise funds from international donors and use them for building the capacity of private aquaculture practitioners and for assisting in establishing the infrastructure of fish farms. For example, the EAGA has conducted a number of training courses and workshops for fish farmers with a fund from the Government of the Netherlands. Knowledge transfer has also been made possible through arranging a visit for a number of private fish farmers to aquaculture facilities in the Netherlands. In addition, the Government of the Netherlands donated two water pumps to help a private fish farmer to establish a recirculation system in Hamool, Kafr El-Shaikh.

8.7 Recent aquaculture/tilapia culture research projects in Egypt

The GAFRD has been involved in many programmes and projects to increase aquaculture productivity, including hatchery development, genetics research and breeding programmes. Universities, research institutes and non-profit research organizations (such as WorldFish) are also engaged in similar projects. Funds for these programmes and projects are provided by the government (e.g. the Science and Technology Development Fund under the Ministry of Scientific Research), international organizations (e.g. the Food and Agriculture Organization of the United Nations (FAO), the United States Agency for International Development, European Union), civil society organizations, and foreign governments. The following list includes some of these projects:

- Improving Employment and Income through the Development of Egypt's Aquaculture Sector (IEIDEAS), implemented by WorldFish and CARE, and funded by the Swiss Agency for Development and Cooperation (December 2011–December 2014).
- National Breeding Program for Genetically Improved Nile tilapia. WorldFish, June 2010–May 2012. Investor: Agricultural Research Center; Partner: Central Laboratory for Aquaculture Research, Abbassa, Egypt.
- Rapid Integrated Assessment (RIA) – Rapid Integrated Assessment of Food Safety and Nutrition in Value Chains. Investor: Australian Centre for International Agricultural Research (ACIAR). June 2012–May 2013. Partners: International Livestock Research Institute, International Food Policy Research Institute, Kafr el-Sheikh University, Royal Veterinary College, University of London.
- Strengthening the Competitiveness of the Fish Sector, 2005–2011, funded by the Government of the Netherlands and based on a bilateral agreement with the Government of Egypt.
- Fisheries and Aquaculture-Oriented Research Capacity in Egypt (FORCE). National Institute of Oceanography and Fisheries, European Union, 2011–2014.

- The Use of Gene Transfer Technology for Producing Cold-tolerant Nile Tilapia (*Oreochromis niloticus*) Strain in Egypt. Oceanography Department, Faculty of Science, Alexandria University. Science and Technology Development Fund, 2014–2016.
- Production and Use of Novel Marine Lactic Acid Probiotics for Improving Growth and Immunity Response of Farmed Fishes in Egypt. Oceanography Department, Faculty of Science, Alexandria University. Science and Technology Fund, 2013–2014.
- Migrant Skills Transfer in the Aquaculture Industry: The case of Greece and Egypt. 1 October 2009 to 31 March 2011. Funded by the European Union through the Joint Migration and Development Initiative.
- BOCI Project Nr. BO-10-006-111, Integrated Aquaculture Egypt, financed by the Ministry of Agriculture, Nature and Food Quality of the Government of the Netherlands.
- ITACA project, Improved Management and Technological Innovation in African Tilapia Farms and Hatcheries, implemented by the National Institute of Oceanography and Fisheries. Co-funded by the European Union through the 10th European Development Fund – the African Component of the ACP Research Programme for Sustainable Development.

9. ISSUES, CHALLENGES AND THE WAY FORWARD

9.1 Issues and challenges

Egypt's aquaculture in general and tilapia culture in particular is subject to technical, administrative, financial, marketing and socio-economic constraints that hamper the sustainable development of the sector (Youssef, 2009). The magnitude and severity of these problems vary from one area to another and from one farming system to another.

Problems related to the aquaculture environment and practice include, among others: (i) competition for water and land with other activities; (ii) bad or deteriorating quality and pollution of aquaculture water; (iii) unexpected changes in water salinity; (iv) most of the farmers lacking basic knowledge about the measurement of water quality parameters (dissolved oxygen, alkalinity, pH, ammonia, etc.), as well as treatment and control procedures; and (v) farmers having limited knowledge about fish stress and disease symptoms.

Problems related to aquafeed include, among others: (i) dependence of the sector on imported feed ingredients; (ii) over 80 percent of feed produced in the form of compressed, sinking feeds, which tend to cause substantial feed waste; (iii) bad handling and storage of feed ingredients and finished feeds in many feed mills; (iv) lack of quality control inspection by government authorities, especially in private feed mills; and (v) poor quality of finished feeds in many private and public mills, mainly due to old technology and/or lack of quality control by the government.

Problems related to seed include, among others: (i) insufficient seed supply to meet the increasing demand; (ii) poor seed quality in many cases; (iii) high mortality of fish seeds during transportation; (iv) high transportation costs and bad roads from hatcheries to farms; and (v) poor experience of farmers in fish breeding.

Problems related to marketing include, among others: (i) negative consumer perceptions about farmed fish; (ii) market monopoly by a few fish traders; (iii) fluctuations in market prices; (iv) markets generally far from fish farms; (v) limited marketing outlets; (vi) limited information on fish marketing; and (vii) lack of export markets.

Institutional and governance problems include, among others: (i) short-term lease of fish farms; (ii) Egyptian law not allowing the use of irrigation freshwater in aquaculture; (iii) lack of comprehensive regulatory control systems that address human food safety hazards in animal feeds (including fish feed); (iv) lack of coherent animal health control system for aquaculture; (v) lack of

effective regime regulating the use of veterinary medicines in aquaculture; (vi) weak and/or inactive regulatory provisions for quality, biosecurity, traceability, and safety of farms and farmed fish products and fish feed inputs; (vii) weak fish farmers' associations; (viii) lack of quality control inspections; and (ix) lack of active NGOs.

Financial problems include, among others: (i) high costs of farm construction and infrastructure; (ii) sharp increase in fish feed prices; (iii) inability of farmers to self-finance their farming activities, and the limited accessibility of fish farmers to credit and finance; and (iv) high farm rental rates.

Technology and human resource problems include, among others: (i) poor extension services; and (ii) lack of capacity building on fish farming, farm management, fish feed technology and feeding strategies.

9.2 Recommendations for action

Feed

Reducing feed costs and increasing feed quality are of prime importance because of the critical role played by feed cost and quality in supporting the overall performance of the sector. The following actions can be adopted by decision-makers and stakeholders to achieve this goal:

- Encouraging “best management practices” (BMPs) for the use of feed and on-farm feeding management through training programmes. Capacity-building programmes for fish farmers and feed producers are crucial in this regard. Training should focus on feed and fertilizer practices, such as sampling of biomass, feed quantities, feeding frequencies, and timing of feeding and fertilization regimes. Regular monitoring and inspection of fish farmers, feed producers, suppliers and ingredients importers by governmental authorities is needed to ensure that they comply with the international quality control standards, such as the Hazard Analysis Critical Control Point (HACCP) and the Code of Practice for Good Animal Feeding (FAO, 1998). Inspections should include, but not limited to:
 - The analysis of feed ingredients for freshness, cleanliness, and exposure to contamination and environmental stressors. The chemical composition of the ingredients should also be regularly analysed.
 - Finished feed distributed in the market or on-farm should be sampled and analysed for protein, lipids, ash, 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 and pesticides, should be checked.
 - Routine inspections on the cleanliness of feed manufacturing premises and equipment.
- A thorough survey of the available conventional and unconventional feed resources in Egypt should be undertaken. An evaluation to establish their availability, accessibility, chemical composition, price and nutritional value for farmed fish should be conducted.
- Promoting investment in the fish feed and supporting industries with the aim of developing national supplies of inputs, including feed ingredients, processed feed, tools and equipment.

Seed

Actions for improving the quality and availability of seed include, but not limited to: (i) providing extension services, particularly to small-scale hatcheries; (ii) generation and dissemination of improved broodstock and seed; (iii) formulating and producing broodstock and larval feeds to meet their nutrition requirements; (iv) training of hatchery managers in hatchery operations and BMPs, especially on the storage and use of hormones; and (v) establishment of an information source on the performance and quality of different hatcheries, the hormones they use (if any), and the fry they produce. Such a source could be used by farmers to obtain and share information about hatchery performance, and therefore incentivize improved practices by hatcheries (Macfadyen *et al.*, 2011).

Water management

Actions for improving the quality and availability of water used by fish farms include, but not limited to: (i) recognizing that fish farming “takes place” in the water rather than “uses up” water; (ii) changing legislation to deem aquaculture an agricultural crop with its own water quota; (iii) addressing existing or potential conflicts between different government agencies regarding governance and utilization of water resources; (iv) encouraging the provision of water quality testing equipment to fish farmers and other stakeholders, accompanied by training and capacity building; (v) adoption of simple but efficient technology for cleaning suspended solids from culture water and use of biofilters for non-suspended matter; (vi) prohibiting the use of harmful chemical herbicides for weed control in waterways and encouraging more environment-friendly methods of weed control (e.g. manual, mechanical and use of grass carp); and (vii) promoting the use of groundwater for agriculture or fish farming in an integrated system.

Market and trade

Actions for improving marketing and exporting potentials include, but not limited to: (i) changing consumer’s negative perception about farmed fish; (ii) initiating appropriate strategies for increasing demand for farmed fish; and (iii) designing an effective marketing/promotion campaign for farmed fish based on appropriate consumer research. Actions to change perceptions about farmed fish could include: (i) better control over the quality of farmed fish imports so as to improve consumer perception about farmed fish in general; (ii) publicizing water quality testing and the results; and (iii) better labelling locally produced farmed fish so that local consumers can easily differentiate between farmed and imported fish products (Macfadyen *et al.*, 2011).

The aquaculture sector should be qualified for export. This can be achieved by adoption of a reform process aiming at converting the conventional aquaculture sector into a market-oriented, internationally competitive business. Improved harmonization and compliance with international standards for exports will be necessary. This will require reforming laws and legislation for monitoring of quality and compliance.

Actions should be taken to reduce fluctuations in prices. Supporting fish overwintering will help even out harvesting volumes throughout the year and enable fish farmers to engage in partial harvesting strategies. Establishment of a database on the timing and volume of harvests from fish farms would be necessary to better understand and manage fish supplies and take the necessary measures to reduce fluctuations in supply.

Improving hygiene and health conditions in wholesale and retail markets and in the transportation and distribution networks can be achieved through providing small loans and/or funds by the government, the private sector or NGOs for the improvement of cold trucks (for transportation and/or to be used as mobile retail fish outlets), refrigerators/cold storage, retail stores, etc.

Developing or improving value addition of farmed fish products can be achieved through investigation into appropriate methods of processing farmed fish (with potential for associated benefits in terms of profits and employment). However, consumer resistance to processed products should be carefully addressed. Assessment and analysis of the feasibility of different forms of processing and the accompanying market promotion and financing would be necessary to overcome the resistance.

Financial services

No insurance system is available in Egypt for fish farmers. State-owned banks and private banks do not generally finance aquaculture enterprises. The banks ask for specific guarantees (such as fixed assets, movable assets or savings certificates), which are usually not affordable by small and medium farmers. Therefore, the establishment of insurance, funding and financing sources for fish farmers and feed producers is timely. However, these activities will require a large investment, and a high degree of coordination between the government and the sector. The government may partially provide

financial support, but sector operators (fish farmers, feed producers, importers and suppliers) should carry some of the financial costs.

Governance and institutions

There are a considerable number of laws, acts, decisions and regulatory provisions that regulate fisheries resources in Egypt, including aquaculture. In order to enhance the effectiveness of these instruments, the government should put more efforts into law enforcement. If necessary, laws and decisions should also be changed or amended.

Legislation should be issued by the government to guarantee the quality, biosecurity, traceability and safety of farmed and fish products. This is to assure that these commodities comply with the international quality control standards.

Legislation and regulations should be issued by the government to guarantee the quality, biosecurity, traceability and safety of fish feeds. These should establish basic procedures and measurements for enforcement, and provide standards, guidelines and recommendations for BMPs concerning fish feed manufacturing, handling, storage and use. Legislation and regulations should be coherent and be complementary parts of the overall national feed/food legislation.

The recent regulation of increasing the duration of aquaculture farm lease contracts to 25 years (Ministerial Decision 831/2013) should be implemented timely and effectively.

Legislation should be changed to treat aquaculture as an agricultural crop with its own water quota. Without the right of farming in freshwater, the export of Egyptian aquaculture products will remain highly limited or banned in potential markets (e.g. European Union).

Legislation regulating the use of veterinary medicines in aquaculture (approvals, restrictions on use, recordkeeping, withdrawal periods and maximum residue limits) should be established or strengthened. This issue should be addressed in the development of the regulatory framework for aquaculture.

The intervention of civil societies such as fish farmers' associations could play a significant role in providing different assistance and services to fish farmers, fish feed producers and other stakeholders. However, most of the associations are inactive or not set up to play such a role. Therefore, the government should start a rehabilitation programme for capacity building and institutional development of these associations and NGOs. Qualified farmer organizations can thus provide different services, including: (i) bulk purchase of feed by the NGOs with price savings for the farmers; (ii) testing the quality of the feed and building the capacity of farmers regarding fish nutrition and feeding management; (iii) buying farming inputs such as seeds, feeds, drugs, fuel and water quality equipment in bulk and selling them to farmers at promotional prices or on credit; (iv) training fish farmers, fish feed producers, traders and other stakeholders on the BMPs in cooperation with funding agents, such as the Social Development Fund, the Egyptian Agribusiness Association and training centres such as WorldFish; and (v) helping in the establishment of some pilot fish farms and providing basic advice to the members on farming practices.

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II. SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN GHANA

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ACKNOWLEDGEMENTS

The authors wish to thank Dr Steve Amisah and Dr Nelson Agbo of Kwame Nkrumah University of Science and Technology, Ghana, and Mr Emmanuel Aryee of the Fisheries Commission for reviewing and providing thoughtful suggestions on an earlier version of this report. Additional thanks are due to the numerous farmers, hatchery managers and fish farm owners in Ghana who directly and indirectly provided information and photos featured throughout the document. Dr Kwamena K. Quagrainie of Purdue University, the United States of America, and several other reviewers and editors contributed immensely to the accuracy of information presented in this report.

1. INTRODUCTION

This report presents an overview of the social and economic performance of tilapia farming in Ghana from a value-chain perspective. The content is based primarily on the synthesis of the relevant literature on fisheries and aquaculture in Ghana, and the information gathered by the authors from interviews and interactions with key leaders of the sector in Ghana from 2009 to 2015. In addition, information is also included from postings on Ghana to the Sustainable Aquaculture Research Networks in sub-Saharan Africa (SARNISSA) listserv, unpublished material from the authors' recently completed and ongoing research involving more than 500 fish farmers, processors and traders, government administrators and field officers, and researchers in Ghana, and the reanalysis of information from a combination of all these sources. The social and economic analysis uses the framework of Trienekens (2011), and draws heavily on almost a dozen recently completed value chain and related studies and reviews of the aquaculture and fisheries sectors of Ghana (Asmah, 2008; Abban *et al.*, 2009; Cobbina, 2010; Ofori *et al.*, 2010; Antwi-Asare and Abbey, 2011; Hamenoo, 2011; Nunoo *et al.*, 2012; Simpson, 2012; Anane-Taabeah, Quagrainie and Amisah, 2015).

Ghana is a middle-income country in Western Africa, sharing boundaries with Togo to the east, Côte d'Ivoire to the west and Burkina Faso to the north. The south is bordered by the Gulf of Guinea, a part of the Atlantic Ocean that endows the country with a coastline of 539 km. Accra is Ghana's capital city and is pivotal to the development of aquaculture in Ghana. Policy decisions related to fisheries and aquaculture are made in the national offices in Accra and implemented by the regional and divisional offices. It is also a major market location for both capture and culture fisheries. Ghana is endowed with Lake Volta, one of the largest artificial lakes in the world. The Volta River basin drains about 70 percent of the entire country (FAO, 2005).

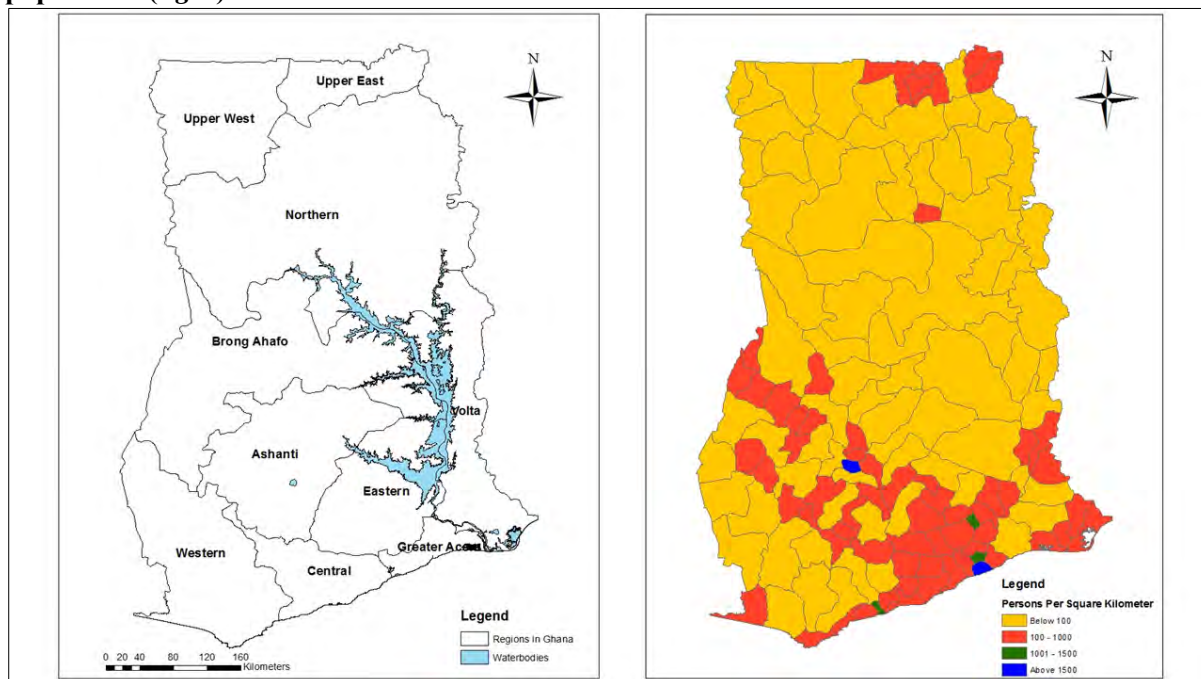
Ghana is divided into ten administrative regions: Greater Accra, Eastern, Central, Western, Ashanti, Brong Ahafo, Volta, Northern, Upper East and Upper West regions (Figure 1). The administrative regions are further divided into 216 districts, or metropolitans, to promote decentralized government. In 2010, the country's estimated population was 25 million (Ghana Statistical Service, 2012). The Greater Accra, Ashanti and Central regions have the highest population density (Figure 1).

Similar to many countries in Western Africa, Ghana has a natural climatic gradient spanning from humid forest in the south to dry savanna in the north. It has good natural resources for both pond and cage aquaculture. The best land and water resources for pond aquaculture are in the southern parts of the country, but many districts that would be considered otherwise unsuitable have irrigation schemes that provide additional opportunities for fish farming (Kapetsky *et al.*, 1991; Asmah, 2008). Lake Volta provides by far the most abundant surface freshwater for cage and pen aquaculture. Additionally, 5 percent of freshwater irrigation sites in the country are targeted for aquaculture (Fisheries Commission, 2012). The vast coastline of the country represents additional potential for aquaculture, although similar to other Western African countries, coastal aquaculture in Ghana is limited in practice (Asmah, 2013).

The history of aquaculture in Ghana has been reviewed previously (FAO, 2005). From its inception in 1953 to the time of the presentation of the FAO national sector overview in 2004, aquaculture had experienced major difficulties and slow progress and represented an effectively negligible component of the 3–5 percent gross domestic product (GDP) contributed by the fisheries sector (Fisheries Commission, 2012). As a result, the contribution of the aquaculture sector to GDP has not been separated from the overall contribution of fisheries. An estimate of 950 tonnes of aquaculture production in 2004 was predominantly (78.9 percent) from the extensive (low intensity) type of ponds with low productivity (averaging 2 500 kg/ha per year), with one commercial cage farm on Lake Volta contributing the remaining 21.1 percent (FAO, 2005). A gap of almost 50 percent between domestic fish requirement and production reported in the early 2000s (FAO, 2005) persisted and widened (Hiheglo, 2008; Cobbina, 2010). The major historical bottlenecks included a lack of commercially compounded feeds, the use of mostly wild-caught fingerlings and inferior strains,

inadequate infrastructure, and weak governance and government institutions with a mandate but little funding for aquaculture research, training and extension.

Figure 1: The administrative regions of Ghana (left) and the geographic distribution of Ghana's population (right)



Source: Prepared by Iris E.M. Fynn.

From the low base of production of 950 tonnes in 2004 (FAO, 2005), it is remarkable that Ghana reported aquaculture production of about 26 000 tonnes in 2012 (Ainoo-Ansah, 2013). In the period 2004–2014, Ghana experienced many events from both public- and private-sector initiatives that set up an enabling political-economic environment for aquaculture development in the years ahead. FAO (2012) reported the “rapid progress” made by Ghana among a few other countries to become a major aquaculture producer in sub-Saharan Africa. Some of the significant events that have put Ghana aquaculture on the pedestal for rapid growth are: (i) the development of a national aquaculture strategic framework (Abban *et al.*, 2006) and a national fisheries and aquaculture policy (Ministry of Fisheries, 2008), culminating in a national aquaculture development plan with a target to increase aquaculture production from 10 200 tonnes in 2010 to 100 000 tonnes by the end of 2016 (Fisheries Commission, 2012); (ii) increasing the adoption of cage culture, which tends to be more productive, larger scale and commercial oriented (Anane-Taabeah, 2012); (iii) progress in the development of a better performing strain (the Akosombo strain) of Nile tilapia *Oreochromis niloticus* (Badjeck and Delaporte, 2012; Attipoe *et al.*, 2013); (iv) the establishment of the first commercial fish feed mill in Western Africa with an installed capacity of 24 000 tonnes¹; and (v) a stabilizing political environment encouraging better governance of fisheries resources, as foreshadowed by the recent reinstatement of the Ministry of Fisheries and Aquaculture Development independent of the Ministry of Food and Agriculture. In addition, from the perspective of the performance of allied sectors, Ghana experienced sustained agricultural growth averaging above 5 percent per year in the period 1985–2010 (Leturque and Wiggins, 2011), an environment that bodes well for aquaculture growth as well.

In spite of what appears to be a significant turnaround of performance and prospects for aquaculture in Ghana over the past ten years, significant setbacks to development remain. Some of the major problems are poor infrastructure (especially bad roads and unreliable electricity supply from the

¹Fish feed mill inaugurated at Prampram. *Business News of Monday*, 15 July 2013 [online]. Accessed 30 October 2013 (www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=279534).

national grid); the high cost of formulated feeds (and still heavy dependence on imported feeds), translating into high and globally uncompetitive price of tilapia produced in Ghana; and the high cost and difficulty of access to credit. Other challenges to aquaculture development include: (i) outdated and inefficient production technology (in particular, a slow pace in the development of tilapia sex-reversal technology, and improper construction and maintenance of ponds); (ii) underfunded, understaffed and under-resourced extension services, leading to weak technical support to small- and medium-scale farmers; (iii) mushrooming of self-styled aquaculture experts filling the vacuum of extension services; (iv) overdependence of the sector on externally driven research and development funding and policy agenda; and (v) a tepid and disorganized dissemination of the improved strains of Nile tilapia, especially to pond farmers.

2. TILAPIA PRODUCTION AND VALUE CHAIN

2.1 Production

Tilapia aquaculture production in Ghana grew rapidly, from 2 000 tonnes in 2006 to over 30 000 tonnes in 2013 (Figure 2). Tilapia has been the dominant aquaculture species; its share in the country's total (inland) aquaculture production² increased from 88 percent in 2006 to 95 percent in 2013 (Figure 2). Other aquaculture species in Ghana include *Clarias gariepinus* (African catfish) and the *Heterobranchus* species and *Heterotis niloticus* (African bonytongue) and, to a limited extent, *Parachanna obscura* (African snakehead) and various *Chrysichthys* species (Claroteid catfishes). Although these non-tilapia species are popular among pond farmers (Frimpong *et al.*, 2011), the increasing share of tilapia in the country's total aquaculture production suggests that the development of other species has not grown as fast as tilapia aquaculture. However, the lack of consistent reporting, especially of pond and tank production, precludes a strong conclusion.

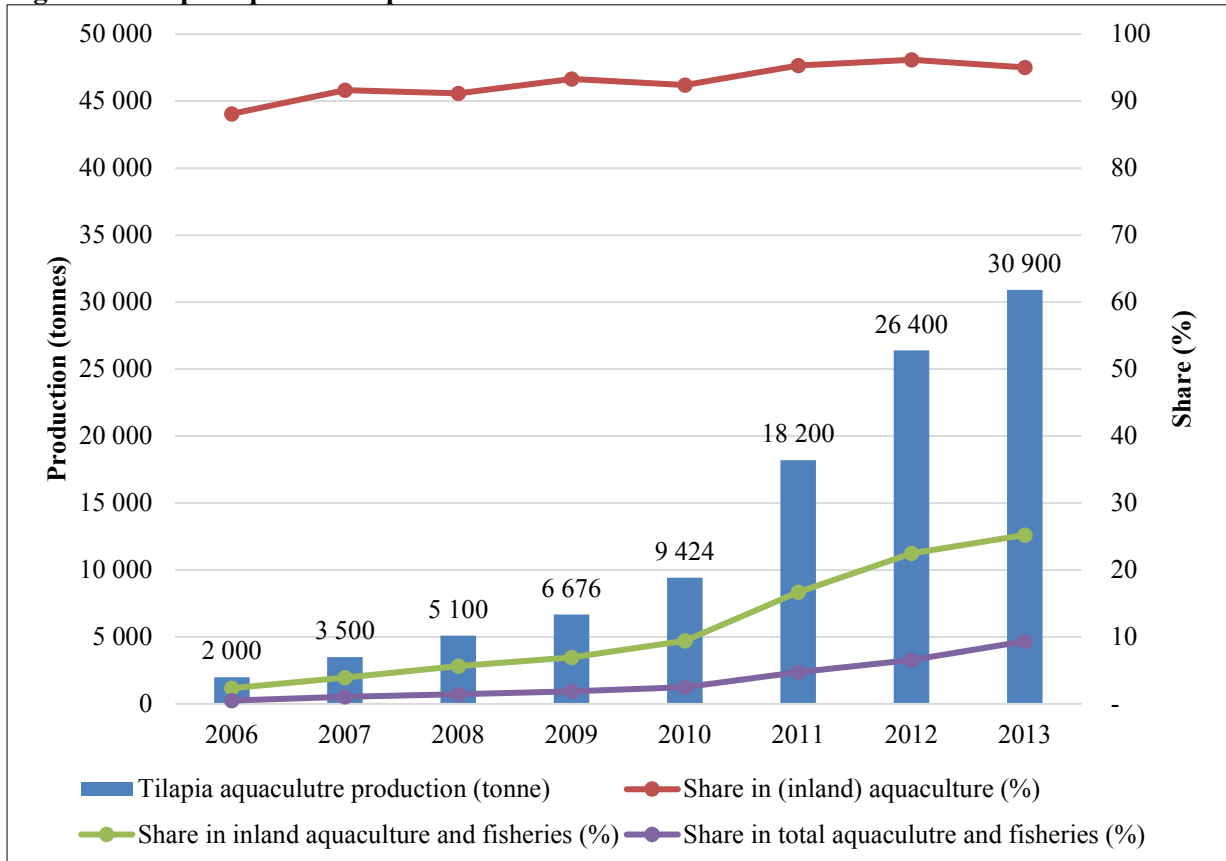
Tilapia aquaculture or aquaculture in general accounted for a small yet increasing share of total fish production in Ghana. From 2006 to 2013, the share of tilapia in the country's inland (freshwater) fish production and total fish production (including inland and marine) increased from 2.3 to 25.2 percent and from 0.5 to 9.4 percent, respectively (Figure 2).

Although the FAO statistics do not provide disaggregated data on tilapia production from capture fisheries, it is believed that capture fisheries, particularly artisanal fisheries, account for most of the tilapia production in the country. Tilapia, primarily the native *Oreochromis niloticus*, *Tilapia zillii* and various species or subspecies of *Sarotherodon*, are common components of inland capture fisheries production (Plate 1). All major waterbodies contribute to tilapia production, but the Volta River makes the most significant contribution. Lake Bosomtwi is also an important source of tilapia for the Kumasi metropolis in the Ashanti region (Antwi-Asare and Abbey, 2011).

According to the estimation of the authors, up to 90 percent of tilapia aquaculture production in Ghana could be from cage systems, with pond culture contributing only 900–2 500 tonnes in 2012.³ It is worth noting that before cage tilapia aquaculture started its surging contribution, Ghana's tilapia aquaculture production in 2004 was 760 tonnes. Based on projections from surveys conducted in 2010–2012 (Anane-Taabeah, 2012), there were between 70 and 100 cage farms in the country. Of these, the top three to four farms appeared to account for approximately half of the total production in 2012.

² According to FAO statistics, aquaculture production in Ghana comes entirely from inland freshwater aquaculture.

³ It was estimated that the number of pond-based aquaculture farms in Ghana was 4 000–6 000 with a total pond area of 600 to 1 000 ha (Asmah, 2008; Ainoo-Ansah, 2013; Awity, 2013). With the average productivity of 1 500–2 500 kg/ha per year (FAO, 2005; Asmah, 2008; Frimpong *et al.*, 2014), pond aquaculture production of tilapia in Ghana was at most 2 500 tonnes/year and could be as low as 900 tonnes/year.

Figure 2: Tilapia aquaculture production in Ghana

Source: FAO. 2015. Fishery and Aquaculture Statistics. Global production by production source 1950–2013 (FishStatJ).⁴

Plate 1

Some of the diverse species of tilapia harvested from the Volta River in Ghana



Courtesy of Emmanuel A. Frimpong and Gifty Anane-Taabeah.

⁴ In: FAO Fisheries and Aquaculture Department [online or CD-ROM]. Rome. Updated 2015. www.fao.org/fishery/statistics/software/fishstatj/en

2.2 Trade

To make up for the deficit in domestic production, Ghana has been importing a substantial amount of fish each year; the 2012 imports were estimated at 175 341 tonnes (Ainoo-Ansah, 2013). Compared with 2003–2004 when imported seafood was 200 000 to 220 000 tonnes and about 40 percent of total fish supply from domestic production and imports (Ashitey, 2004), the 2012 import was a significant decrease and even more so as a proportion of total consumed seafood reported in Ainoo-Ansah (2013).

The main species imported into the country include red snapper, chub and horse mackerel, among others. The major regions from which seafood is imported are Africa (Angola, Mauritania, Morocco, Namibia and Senegal) and the European Union (Spain and the Netherlands) (Ashitey, 2004).

As the cost of domestically produced tilapia is high (Hiheglo, 2008; Hamenoo, 2011), Ghana started importing tilapia from Asian countries in recent years (e.g. China and Thailand). According to information from the Fisheries Commission in 2010 (also reported by FAO, 2005), there have been efforts to restrict tilapia imports into Ghana in order to protect the country's fledgling aquaculture industry. However, it appears that the restrictions have not always been effective. Data from China Customs (extracted from the Global Trade Atlas on 10 June 2014) indicate that China exported about 5 000 tonnes of frozen tilapia (US\$6.1 million) to Ghana in 2012 and 2 546 tonnes (about US\$4.9 million) in 2013. Asmah (2008) reported that all frozen tilapia in large-scale cold stores in the Ashanti region were imported from Thailand.

It is worth noting that foreign tilapia could enter Ghana through intracontinent trade. For example, Ghana's western neighbour, Côte d'Ivoire, imported significantly more tilapia from China than Ghana during 2012–2013 (Table 1). As the movement of food products such as fish crossing borders between Ghana and its neighbours is nearly impossible to restrict, a part of Côte d'Ivoire's tilapia imports may end up in the domestic market of Ghana.

Table 1: China's export of frozen tilapia to selected Western African countries

Country	2012		2013	
	Value (US\$)	Volume (tonnes)	Value (US\$)	Volume (tonnes)
Burkina Faso	950 400	264	14 775 510	4 112
Côte d'Ivoire	28 807 341	15 460	38 723 718	17 381
Ghana	6 166 812	5 003	4 866 214	2 546
Togo	2 253 459	1 323	4 078 327	1 834

Source: China Customs (extracted from the Global Trade Atlas).

Ghana's seafood export constitutes primarily tuna products, mostly canned but also some fresh and frozen forms. Since 2002, Ghana has consistently exported over 40 000 tonnes of tuna (Antwi-Asare and Abbey, 2011). The export of fresh farmed tilapia was virtually non-existent owing to limited production and high internal demand (Antwi-Asare and Abbey, 2011; Anane-Taabeah, Quagraine and Amisah, 2015). It has been reported that smoked catfish and salted tilapia have been exported to the European Union and the United States of America and sold in Ghanaian food stores (Antwi-Asare and Abbey, 2011). The export of salted tilapia to other Western African countries, especially Togo, has also been reported. Yet quantitative data on such exports are not readily available.

With regard to the export of tilapia, Hamenoo (2011) indicated that fish farmers in the country are currently producing tilapia at a cost that is too high to be competitive on the international market. In spite of the potential challenge posed by the high cost of production, large producers in Ghana have expressed interest in exporting frozen tilapia to other ECOWAS (Economic Community of

Western African States) countries because of the decreasing ability of the local market to absorb the increasing production.⁵

2.3 Tilapia value chain

The fishery value chain in Ghana, and in particular the tilapia value chain, has been analysed quite comprehensively in recent years (Antwi-Asare and Abbey, 2011; Anane-Taabeah, Quagraine and Amisah, 2015). Antwi-Asare and Abbey (2011) distinguished two value chains for tilapia in the country, and defined the farmed tilapia value chain as the modern urban-biased value chain in contrast with the artisanal value chain based on fish captured from lakes and rivers. When carefully examined, however, the tilapia value chain in Ghana can be described as a much more complex chain of activities, from input supply to consumption with several short chains (e.g. the artisanal and farmed tilapia value chains) typical of many value chains.

The tilapia value chain begins with input suppliers at the top of the chain supplying input for capture and/or culture of tilapia. For capture fisheries, input suppliers focus on gear such as nets, twines, and ropes and traps, among others. Input suppliers for aquaculture on the other hand are more diversified and provide inputs including broodstock, fingerlings and feed, in addition to providing harvesting gear (Anane-Taabeah, Quagraine and Amisah, 2015).

Once the fish is harvested, distinct value chains can be identified for both the artisanal value chain and the farmed tilapia value chain. Thus, the modern urban-biased value chain may be described as one type of the farmed tilapia value chain (Anane-Taabeah, Quagraine and Amisah, 2015). It appears that the modern urban-biased value chain has the advantage of traceability in terms of products and profit flow through the chain. Particularly for farmers that have their own distribution or sales points, product quality can be improved from consumer feedback and profit margins can be monitored effectively. Both the artisanal and modern urban-biased value chains have similar and overlapping actors and key players. For instance, traders in both the artisanal and modern urban-biased value chains perform similar roles and maintain their marketing power within the value chain.

On the other hand, the role of processors varies significantly between the two value chain types. While processors in the artisanal value chain actively undertake one of the five traditional processing methods – salting, drying, smoking, frying and fermenting (Antwi-Asare and Abbey, 2011) – processors in the farmed tilapia value chain mainly engage in gutting and scaling of the fish (Anane-Taabeah, Quagraine and Amisah, 2015) and are often traders as well. In fact, processors in the farmed tilapia value chain are usually not distinguished from traders, and they have often been more conveniently considered as the same entities (Hamenoo, 2011; Simpson, 2012; Kassam, 2013). This is because almost all farmed tilapia is either sold fresh without ice or fresh on ice (Abban *et al.*, 2009; Simpson, 2012; Anane-Taabeah, Quagraine and Amisah, 2015), similar to what has been reported elsewhere in Africa (Macfayden *et al.*, 2012). Fish not considered fresh may be preserved by freezing, salting and drying, or smoked (Abban *et al.*, 2009). As observed by Antwi-Asare and Abbey (2011) and Anane-Taabeah, Quagraine and Amisah (2015), the tilapia value chain mainly serves local and national markets, with little or no focus on international markets. Particularly for fresh tilapia, the local demand has been high until recently and the uncompetitive prices discourage export.

Feed producers

In 2013, there were about 12 commercial feed suppliers (brands) in Ghana, only one of which was a local producer (Plate 2). Almost all cage farmers use commercial feeds. However, Asmah (2008) reported that only about 2 percent of non-commercial farmers (who constituted 97 percent of farmers the author surveyed in 2006) used commercial feeds.

⁵ Personal communication by M. Amechi from Tropo Farms on 22 February 2014 via SARNISSA (Sustainable Aquaculture Research Networks in sub-Saharan Africa).

Plate 2
Sample commercial fish feeds in Ghana (packed in 15–25 kg bags)



Courtesy of Emmanuel A. Frimpong.

About 70 percent of commercial feeds used in the country are imported with the remaining 30 percent being produced locally using local and/or imported ingredients. The major aquafeed companies and brand names on the Ghana market include Cargill, Coppens and Raanan. Other known names are Biomar, China Tilapia Feed, Guabi (Pira), Inter-aqua, Nicoluzzi, Zeigler and PT Matahari Sakti (launched in 2014), Aqua Feed and Aqua Engine.

Raanan Fish Feed Ltd, the first fish feed company in Western Africa, is the only locally established company with an installed capacity of 24 000 tonnes per year. In 2012, Raanan Fish Feed's actual production was about 500 tonnes per month,⁶ and in 2013 it was reported to be 1 000–1 400 tonnes per month. Some of the other companies listed are planning to or may have already moved to local production (Awity, 2013).

Tilapia farmers also use imported feeds from Brazil, China, Denmark, France, Indonesia, Israel, the Netherlands, the United States of America and Viet Nam (Hamenoo, 2011; Awity, 2013; Anane-Taabeah, Quagrainie and Amisah, 2015).

As of 2013, large-scale cage farms use mostly imported feeds (Kassam, 2013). Larger pond farms such as Kumah Farms and Bosomtwi Integrated Aqualife Village make their own custom fingerling and grow-out feeds (Plate 3) and also purchase various commercial feeds (Agbo, 2009; Leschen, 2011; authors' interviews). Their stated motivation for on-farm feed manufacturing is to cut cost.

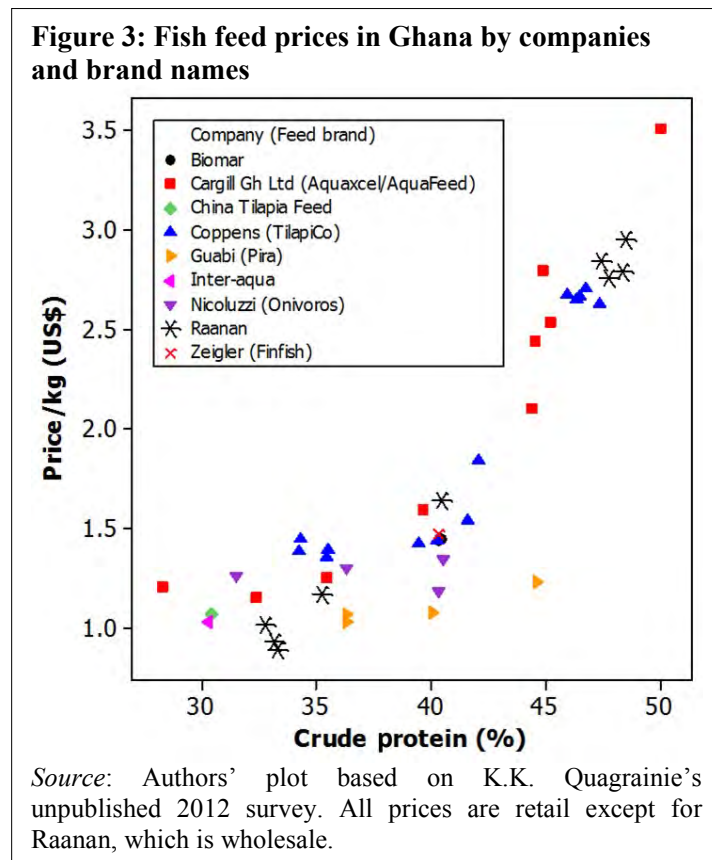
Plate 3
Left: Bosomtwi Integrated Aqualife Village in January 2009 (under construction)
Right: Kumah Farms in January 2012



Courtesy of Emmanuel A. Frimpong.

⁶ Personal communication from J. Magnee via SARNISSA in 2012.

The price of fish feed varies by crude protein content (up to 50 percent but most commonly 30–40 percent) and pellet size (0.3–8.0 mm), where the smallest pellet sizes are usually associated with high protein content and used as fry and fingerling catfish or tilapia feeds. Generally, feeds with higher protein content tend to be more expensive, but the prices vary across different brands (Figure 3).



Feed prices were high in 2012, with 30–35 percent protein feeds at about US\$1.3/kg, and fry and fingerling feeds up to US\$3–3.5/kg. When considering the feed conversion ratio of the 1.5–2.0 range for cage farms with feed constituting 65–70 percent of the production cost in cages, it is apparent that it is difficult to produce tilapia in cages in Ghana at less than the US\$2/kg mark for the break-even cost of production.

Prominently missing from the market is low protein feeds. Cargill sold a 28 percent protein feed in 2012, but the price was very similar to the 32 percent feed. By 2015, Raanan Fish Feed also had a 28 percent feed on the market, which was used primarily by cage farmers to slow down growth and reduce feeding costs when harvesting has to be delayed. Lower protein feeds at 25 percent crude protein content are being used successfully for grow-out and fattening in ponds in Egypt (El-

Sayed, 2013) and could be a useful addition for pond-based tilapia farming in Ghana. The critical mass is needed in the pond farming sector to absorb such a product and attract companies to that end of the product spectrum. The data discussed here are for a mix of catfish and tilapia feeds. Compared with catfish feed, tilapia feed is slightly cheaper because the protein content of catfish feed is usually higher.

Farmers are usually responsible for transporting feeds from retail stores to their farms. Feeds are typically purchased on a cash basis (Anane-Taabeah, Quagraine and Amisah, 2015). The concentration of major feed distributors in Accra and Tema implies that regional differences in feed prices exist. This would generally add to the cost for farmers in regions other than Greater Accra, Eastern and parts of the Volta regions. Outside of these regions, farms are almost all pond based.

Seed producers

Seed is one of the value chain components where the private sector has taken a strong lead. The authors identified 22 private hatcheries and 4 public ones that altogether produced an estimated 100 million fingerlings in 2013, about 4 percent of which was contributed by public hatcheries (Plate 4; Plate 5). This estimate includes five medium to large cage farms (e.g. Tropo) that produce a significant portion of the total tilapia fingerling supply in the country and all of their own fingerlings, as the supply of quality fingerlings is still limited in the country. The top 7 (in terms of production capacity) of the 19 hatcheries identified were all private and accounted for 80–93 percent of fingerling production.

Plate 4

Left: Data Stream Farm, Senkyi, Eastern region
Right: Bosomtwi Integrated Aquaculture Village, Abotem, Ashanti region



Courtesy of Gifty Anane-Taabeah and Emmanuel A. Frimpong.

Plate 5

The government's Pilot Aquaculture Centre hatchery in Tano Odumasi, Ashanti region, 2009

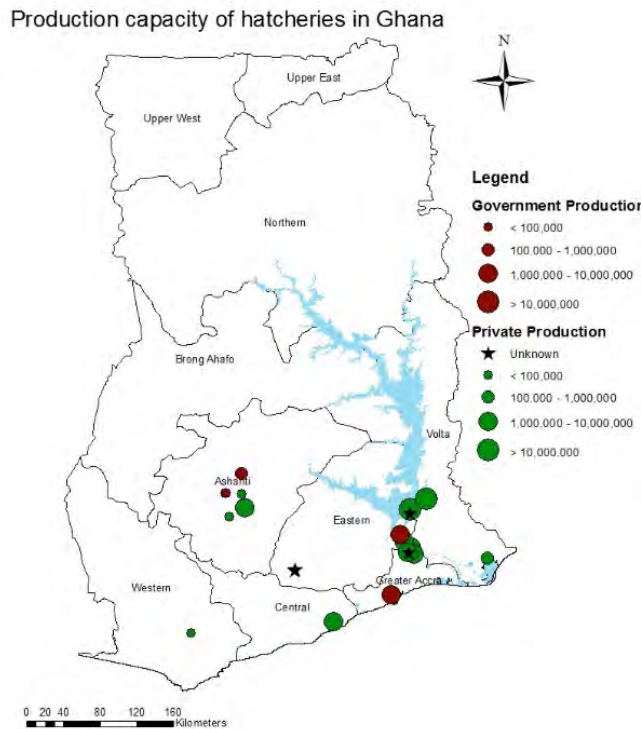


Courtesy of Emmanuel A. Frimpong and Steve Amisah.

Antwi-Asare and Abbey (2011) identified three tilapia hatcheries on Lake Volta in 2011, with one producing over 1.5 million fingerlings per year. During a survey in 2012, a major hatchery located in Akuse in the Eastern region reported a production estimate of 1 million fingerlings per month.⁷ Over 70 medium cage farmers, as well as pond farmers, depend on commercial hatcheries for fingerlings. The country has three major government institutions responsible for producing *Oreochromis niloticus* fingerlings for sale to farmers, and the Aquaculture Research and Development Centre of the government's Water Research Institute is primarily in charge of breeding and supplying broodstock of the Akosombo strain of *O. niloticus* to hatcheries.

Together with the government hatcheries, the number of well-known or otherwise self-identified commercial tilapia hatcheries in Ghana is in the range of 20 to 30. Hatcheries are located, in most cases, close to large or clustered fish farms (Figure 4). The government hatcheries are located in the Greater Accra, Eastern and Ashanti regions and serve farmers nationwide. Most of the remaining hatcheries are located around Lake Volta, precisely in the Eastern and Volta regions. Tilapia fingerlings (mostly monosex, all male) of about 2–5 grams are sold. However, because of high demand, “fingerlings” smaller than 2 grams are frequently sold to farmers (Anane-Taabeah, Quagrainie and Amisah, 2015). Fry of 0.5–1 grams have been advertised by hatcheries. Stocking small tilapia fingerlings or fry probably contributed to the increasing mortalities in Lake Volta, which became a discussion topic for SARNISSA in late 2013 and early 2014. For pond farmers, the absence of nurseries in the value chain means that they would usually stock very small fingerlings, and potentially high mortalities may occur without being recognized until it is too late. There is an opportunity for the development of a nursery subsector that nurse fry or small fingerlings to larger size where they can be graded, sorted and sold to pond farmers. However, without a convincing economic analysis of the nursery business, the opportunity has yet to attract the attention of investors.

⁷The authors' unpublished data.

Figure 4: Geographic location of fish hatcheries in Ghana

Source: Prepared by Iris E.M. Fynn based on data compiled from farmer interviews and public sources by the authors.

The price of fingerlings usually includes grading and packaging, while buyers bear the cost of transportation to their farms (Plate 6 and Plate 7). Tilapia fingerlings are typically about half the price of catfish fingerlings. The factors that determine the price for these species appear to be the effort involved in successfully producing fingerlings and the cost of raising fingerlings to market size. As pond farmers are becoming more conscious of the necessity to grow all-male fingerlings and better-quality strains of tilapia, it is likely that an additional pricing premium will be charged by hatcheries able to guarantee faster growing strains and a higher success of sex reversal; accordingly, the differences in price between tilapia and catfish fingerlings will probably get smaller.

Hatcheries rarely supply fingerlings on a credit basis. A common practice is that farmers

give advanced payments to hatcheries before the fingerlings are supplied at a later date (Anane-Taabeah, Quagraine and Amisah, 2015). This arrangement is encouraged by the prevailing scarcity of good-quality fingerlings. In general, farmers take more risk than hatcheries in such transactions because the orders are not always met in a timely fashion. On the other hand, if a farmer decides not to take an order, it is highly likely that the hatchery will find an alternative buyer already in the queue.

Plate 6

Grading fingerlings at the government's Pilot Aquaculture Centre



Courtesy of Francis Adjei, Manager of the Pilot Aquaculture Centre.

Tilapia farmers

Kassam (2013) differentiated aquaculture engagements in Ghana into four categories: (i) small-scale pond farms owned by poor farmers with minimal use of inputs; (ii) small-scale pond farms owned by relatively well-to-do farmers who use better management practices; (iii) small- and medium-scale cage farms mostly owned by Ghanaians whose socio-economic circumstances and education levels are better than pond farmers; and (iv) large-scale cage farms owned mostly by foreigners. Anane-Taabeah (2012) considered all cage farms commercial ventures and categorized them into three

groups: large scale (greater than 50 cages per farm); medium scale (between 10 and 50 cages); and small scale (less than 10 cages). Policymakers in Ghana (Fisheries Commission, 2012) have also used various criteria to define small-, medium- and large-scale farms.



Small-scale pond farms with small volume sales of fresh fish at the farmgate to neighbours and small-scale traders/processors have difficulties in establishing necessary linkages to cold chains and urban markets because of a number of constraints, including unpredictable production volume and quality, wide geographic dispersion and the lack of infrastructure, leading to large transaction costs for coordination. Such farmers therefore face a high risk of post-harvest losses that forces them to sell on credit to traders or be price takers, with traders being opportunistic beneficiaries and not always honouring the terms of payment (Simpson, 2012; Anane-Taabeah, Quagraine and Amisah, 2015). Simpson (2012) also reported that the small- and medium-scale cage farms face similar constraints, with processors and traders being keenly aware of the perishability of the product once harvested, forcing farmers at the end of the day to sell fish at low prices.

According to the Fisheries Commission in 2006 (Table 2), the aquaculture sector in Ghana had seven main high-performing commercial farmers and 2 869 small-scale farmers. In terms of farming systems, the industry had 180 cages with a total volume of 5 266 m³ and 76 pens with a total area of 6.73 hectares. Anane-Taabeah (2012) estimated slightly more than 70 cage and pen farms, but no rigorous estimate of volume was made in that study. Data provided by the Fisheries Commission in the period 2006–2009 suggested that pond fish production was highest in the Western region by the number of farmers and ponds (1 650 and 2 550, respectively). In terms of surface area, the Brong Ahafo region had the largest production capacity of about 139 hectares. Fynn (2014) updated estimates of pond numbers in the regions putting Ashanti region at the top with 7 084 ponds, followed by Brong Ahafo (5 975) and Eastern (5 393). This suggests that pond numbers have been rapidly increasing in the past decade or so, and previous estimates might have missed many ponds.

Table 2 provides the breakdown of fish farms by the regions with active fish farming in 2006. These numbers have often been cited with usually small, but sometimes large and unexplained variations. Other reports of the number of pond-based farms in Ghana variously estimate 4 000–6 000 with a total pond area of 600 to 1 000 ha (Asmah, 2008; Abban *et al.*, 2009; Ainoo-Ansah, 2013). Adding to the confusion, many reports seem to consider the number of ponds and the number of farms

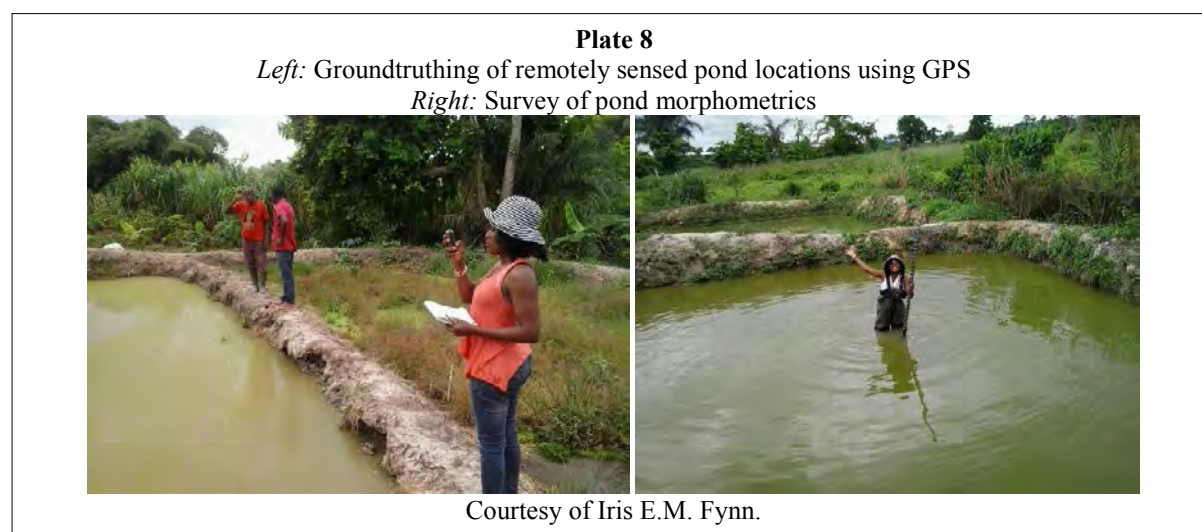
interchangeable numbers. From what is known, there is no published authoritative census of fish farms in Ghana that is systematically updated. Although Asmah (2008) reported an annual rate of growth in pond-based fish farms at 16 percent in 2006 in the Ashanti region, corroborating Fynn (2014) that the Ashanti region may have surpassed the Western and Brong Ahafo regions in the number of ponds. The growth rate of farms in other regions have not been reported previously, and all estimates may be moderated significantly by high attrition rates of pond farms (authors' unpublished data).

Table 2: Fish farm data by region in Ghana in 2006

Region	Fish farmers (number)	Ponds (number)	Functional ponds (number)	Total surface area (ha)
Ashanti	304	746	746	118.71
Brong Ahafo	333	761	761	138.63
Central	253	633	610	39.91
Eastern	107	311	311	20.35
Greater Accra	64	233	207	39.50
Volta	143	308	254	67.35
Western	1 650	2 550	2 550	59.10
Upper East	15	25	25	7.52
Total	2 869	5 567	5 464	491.07

Source: Lionel Awity, Fisheries Commission, unpublished 2006 data.

The Fynn (2014) study⁸ used satellite imagery in combination with ground surveys to quantify the number of ponds and their area in the country and concluded that there are more ponds in most regions than previously assumed (Plate 8). However, the study did not attempt to separate functional and non-functional farms.



Field observations indicate that a considerable number of pond farms undertake intensive culture in tanks, though primarily of catfish (Plate 9). No data on such tank production have been reported.

Likewise, integration of fish farming with other agricultural activities such as crop farming and livestock rearing is also common, but not consistently quantified nationwide.

⁸ The study was led by researchers of Virginia Polytechnic Institute and State University (including the authors) in collaboration with researchers of the Kwame Nkrumah University of Science and Technology, Ghana, USAID, and AquaFish Innovation Lab.

Plate 9
 Demonstration of catfish production in tanks in an AquaFish Innovation Lab in 2012



Courtesy of Emmanuel A. Frimpong.

Demographically, farmers are about 90 percent male with the majority in the 40+ age group. All levels of education are represented; however, the higher levels (tertiary) are more strongly associated with the large-scale cage farms.

Cage farming accounted for over 95 percent of tilapia aquaculture production in Ghana in recent years. FAO (2005) reported that one large cage farm accounted for over 20 percent of the total 950 tonnes of tilapia aquaculture production at that time. In 2012, with 70–100 cage farms and 3–5 large-scale farms, production from the largest cage farm was estimated at between 5 000 tonnes and 6 000 tonnes, amounting to about 20 percent of the approximately 27 000 tonnes of production reported. The top three to four farms may currently account for about 40–50 percent of the total production.

Large-scale cage farms provide limited technical assistance and inputs (e.g. surplus fingerlings) at discounted prices to small-scale farmers in their communities. However, large-scale farms did not play a significant national role in research and training of small-scale farmers. Recent reports indicate that at least one hatchery (Ainoo-Ansah Farms) and one feed manufacturer (Raanan Fish Feed) are stepping up farmer training in partnership with a government university and the Fisheries Commission's Pilot Aquaculture Centre hatchery, respectively. Raanan is also partnering with scientists to evaluate the performance of a 25 percent protein feed for pond-based tilapia farmers.

Tilapia processors

Except for packaging on ice to preserve the freshness of fish during sales, there is not much opportunity for storage and later sales once small-scale cage farms harvest their fish (Plate 10). The risk of cage farmers receiving disadvantageous prices is compounded by the fact that the partial harvest of cages is generally infeasible, and consequently 2–4 tonnes of fish could be hauled to shore in a single harvest event (Rao, Perrino and Barreras, 2012; Simpson, 2012). Large cage farms that own cold trucks and cold storage facilities and have outlets in urban centres are to some extent immune to the risk of the large supply depressing the price experienced by pond farms and small- and medium-scale cage farms (Kassam, 2013).

Fish processors are recognized as part of the post-harvest sector in Ghana (Cobbina, 2010). Fish processing is a women-dominated activity (Cobbina, 2010; Antwi-Asare and Abbey, 2011; Anane-Taabeah, Quagrainie and Amisah, 2015) (Plate 11). Processors in the tilapia value chain are usually not part of any recognized association. Thus, determining the number of people employed in the sector is challenging, and at best only estimates can be provided. Anane-Taabeah, Quagrainie and

Amisah (2015) found that processors in the farmed tilapia value chain work in clusters or groups of about ten women. To reduce post-harvest losses, most tilapia from capture fisheries is processed mainly through salting and drying, and smoking before sales to consumers (Antwi-Asare and Abbey, 2011).

Plate 10

Interviewing a small-scale cage farmer on Lake Volta in 2010



Courtesy of Gifty Anane-Taabeah.

Plate 11

Tilapia processing (scaling and gutting) primarily done by women

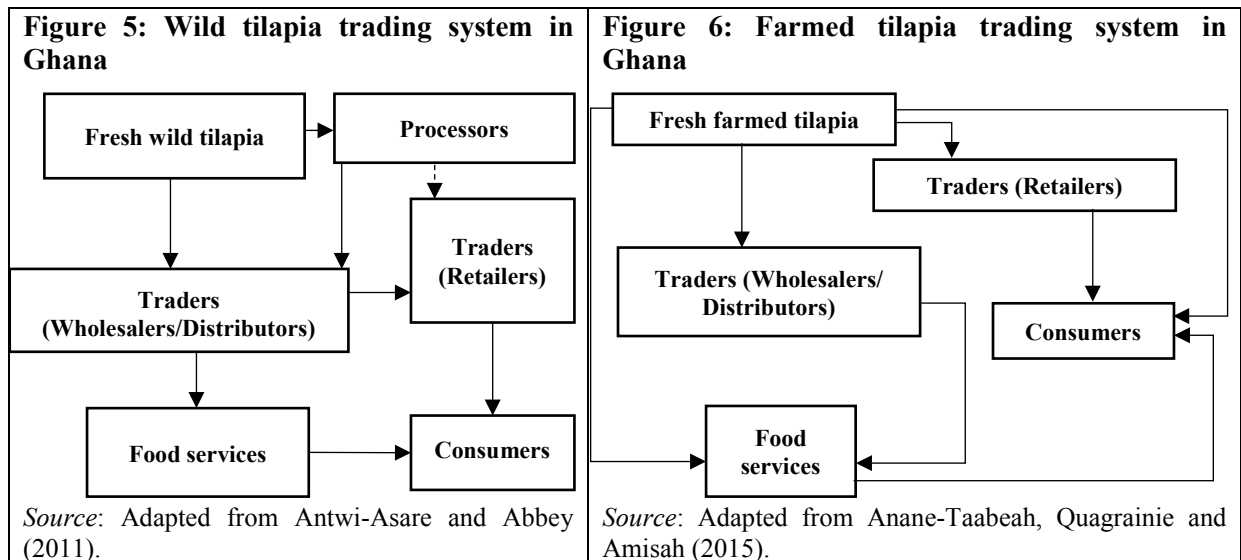


Courtesy of Gifty Anane-Taabeah.

Tilapia traders

The tilapia trading system in Ghana varies slightly between captured fisheries and cultured fisheries. Traders can be classified into three groups: wholesalers, distributors and retailers, depending on the quantity of fish they purchase for sale (Antwi-Asare and Abbey, 2011; Anane-Taabeah, Quagraine and Amisah, 2015).

A major difference between tilapia trade in wild-caught and cultured fish is that processors play a prominent role in the former. Processors in the captured fisheries sector purchase fresh tilapia from fishers, and after the fish has been processed they sell it mostly to wholesalers (Figure 5). However, because farmed tilapia is marketed mostly fresh (Abban *et al.*, 2009; Anane-Taabeah, Quagraine and Amisah, 2015) with little value addition, the function performed by processors in the tilapia trade is mostly lacking in the farmed tilapia sector (Figure 6).

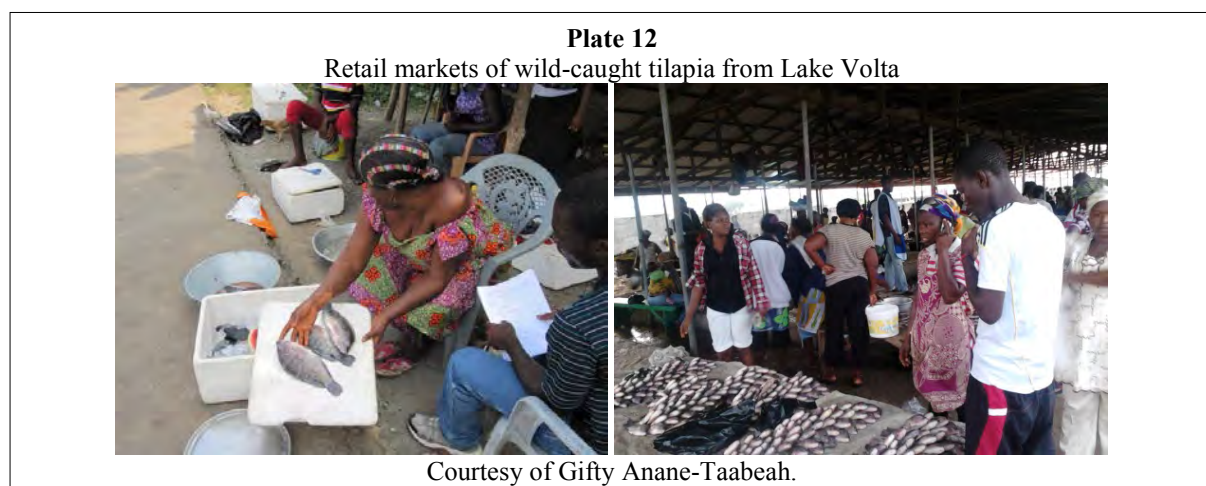


Asmah (2008) estimated the number of tilapia traders in Ghana to be about 6 000 in 2006, excluding traders who do not travel to fish landing sites. Many tilapia traders do not discriminate between farmed and wild tilapia; thus, it may be assumed that the same number of traders deal in both farmed and wild tilapia.

Tilapia price determination is usually done using two main approaches: existing market price approach and the cost-plus (or percentage markup) approach. Farmgate prices are often influenced by market prices (Anane-Taabeah, Quagraine and Amisah, 2015). However, large commercial fish farms are able to dictate their farmgate prices, which traders have no control over. Wholesalers and retailers usually use the cost-plus approach in fixing their prices (Anane-Taabeah, Quagraine and Amisah, 2015).

Asmah (2008) found that trading in cultured tilapia was more profitable than trading in wild tilapia, with gross profit margins of GHC 0.49/kg and GHC 0.25/kg, respectively, for wholesalers and retailers combined. This was due to lower wholesale prices for cultured tilapia as reported in 2006.

Interviews conducted at a retail point by the authors in 2012 revealed that some traders preferred trading wild tilapia to cultured tilapia (Plate 12). The size of fish was the major determinant of preference. Apparently, tilapia that reached major retail centres were usually large sized. Consequently, price determination was easier for traders. On the other hand, farmed tilapia came in various sizes and was usually dominated by smaller sizes, which traders and consumers alike wanted to purchase cheaply.



Tilapia consumers and prices

Asmah (2008) reported that fish was the most preferred protein among the main sources of animal protein (including fish, meat products such as beef, pork, lamb and mutton, poultry products, and “bushmeat” from the wild such as grass cutters, wild fowls and antelopes) consumed by surveyed consumers in Ghana, accounting for at least 60 percent of households’ protein intake. Hamenoo (2011) reported that 52 percent of 44 consumers surveyed showed preference of tilapia over other fish species on the market and that consumer expenditure on fish products was affected by family size and income.

Generally speaking, tilapia was more expensive than most other frozen or smoked fish (Asmah, 2008). Compared with the wholesale prices of 16 common marine fishes caught in the waters of Ghana presented in Aheto *et al.* (2012) whose nominal median price was about US\$2/kg, tilapia can be deemed an expensive fish in the country. Widespread preference for tilapia over other fish species and various types of animal protein was documented in Hamenoo (2011). According to the comparison in Asmah (2008) and Hamenoo (2011), fresh tilapia cost at least twice as much as beef on a per kilogram basis. The high price of tilapia was one of the major reasons that some people did not regularly eat it (Asmah, 2008).

In 2013, catfish was more expensive than tilapia, and based on the authors’ observation, this seemed to be true even when both fish were smoked. Thus, farmers who practice polyculture of tilapia and catfish often consider their business more profitable.

Despite high input costs, particularly high feed costs of farmed tilapia, fresh tilapia sold by fishers in retail markets is often more expensive than farmed tilapia. This partly reflects the size premium of wild-caught over farmed tilapia, which tends to be a smaller size. Large-size tilapia is preferred by consumers in Ghana (Darko, 2011; Anane-Taabeah, 2008). Asmah (2008) noted that the average size of tilapia preferred by consumers is at least 200 grams. Size-related preference for tilapia appears to be influenced by a market segmentation of consumers driven by the specific use of the fish. Households may demand sizable fish (about 200 grams); this would influence retailers who mostly target this sector of the market. A tilapia hatchery and cage farm manager⁹ noted that women market traders did not want big fish and insisted that fish be harvested at an average weight of 300 grams. On the other hand, more affluent consumers who patronize restaurants and “tilapia joints” with grilled tilapia prefer and often source larger-sized tilapia (600 grams to 1 kilogram).

Given the same size, wild-caught fresh tilapia may still be more expensive than farmed tilapia because of consumers’ preference for wild tilapia (Anane-Taabeah, 2008; Darko, 2011; Kassam, 2013). Generally speaking, in Ghana wild tilapia is deemed better quality in terms of taste (less oily), texture (firmer) and appearance. Wild tilapia is also perceived to be healthier and has a longer shelf-life. In terms of taste (oiliness) and shelf-life, Kassam (2013) found that pond-raised tilapia is of better quality than cage-raised tilapia. The authors’ analysis indicates that for small-size fish (below 200 grams), the prices of farmed and wild tilapia may not be different, and farmed tilapia could be priced slightly above wild tilapia.

Unlike wild tilapia, which is usually sold in baskets weighing about 10 kg (Antwi-Asare and Abbey, 2011), farmed tilapia is mostly sold on a per kilogram basis, particularly at farmgate and at wholesale and distribution points.

The prices of farmed tilapia do not vary significantly between farmgate and wholesale levels, but are higher at retail, even if retailing is conducted by a subsidiary of the fish farm. Table 3, which is an example of tilapia prices posted at the outlet (wholesale/retail point) of a large cage farm in 2012, shows significant markups between wholesale and retail prices.

⁹ Personal communication by N. Murali, the manager of Volta Breams Ltd, a tilapia hatchery and cage-based production business in Ghana, through a post on SARNISSA on 4 March 2014.

Table 3 also indicates price premiums for large-size tilapia. Size differentiated pricing schemes developed by large cage farms (such as the one in Table 3) have been used widely at the farmgate and wholesale/retail outlets of most cage farms, but there are variations in the range of sizes labelled in various categories across the country, which cause confusion and price setting and negotiation problems (Kassam, 2013). Some pricing schemes break Size 3 in Table 3 (i.e. 600 grams to 1 kg) into 600–800 grams and 800+ grams. Sizes less than 250 grams or so are sometimes split into economy (200–250 grams), small (100–200 grams) and “school boys” (< 100 grams) (Simpson, 2012; Cocker, 2014). Economy through school-boy sizes were 35–47 percent of total harvest weight of two small-scale cage farms (Simpson, 2012) observed in the town of Achavanya in the Volta region.

Table 3: Wholesale and retail farmed tilapia prices at a major outlet in May 2012

Size	Retail price (GHC/kg)	Wholesale* price (GHC/kg)
Regular (150–250 grams)	7.10	5.90
Size 1 (250–400 grams)	7.70	6.40
Size 2 (400–600 grams)	8.90	6.80
Size 3 (600 g–1 kg)	10.60	7.00

Source: Authors' compilation.

*Purchase of over 25 kg crates considered a wholesale sale. US\$1 = GHC 1.86 in May 2012.

The prices of farmed tilapia vary across market locations. Large urban centres such as Accra usually offer higher prices than rural areas (Abban *et al.*, 2009). Pond-grown tilapia are generally cheaper than cage-grown tilapia because pond tilapia farms predominantly produce small-size fish to serve rural markets. In regions with significant pond tilapia farming, the typical tilapia size is small (about 200–250 grams). The farmgate sales in these regions are a mix of wholesale to processors or traders, small restaurants known as chop bars, and retail to individuals including neighbours.

The authors have surveyed prices in five regions (Ashanti, Brong Ahafo, the Central region, the Eastern region and the Western region) from 2011 to 2013 through questionnaires administered to 200 pond farmers. The interviews revealed that regional fisheries offices and even farmers' associations have attempted to regulate the farmgate prices in the past, probably because of the facilitative roles they were supposed to play in connecting farmers to traders and to gather sufficient volumes of fish across farms for larger buyers (Kassam, 2013). Not all farmers found price regulation acceptable, and many often sold their produce at preferred prices when they could find their own buyers.

Because of a high rate of inflation in Ghana (average 12.2 percent per year during 2004–2013) and an almost constant depreciation of the Ghana cedi (GHC) against the United States dollar (US\$), prices reported over a period of years are difficult to compare. The authors' analysis of data on farmed tilapia prices provided by the literature or compiled by the authors (Kaliba *et al.*, 2007 [2005 data]; Cobbina, 2010 [2009 data]; Antwi-Asare and Abbey, 2011 [2001 data]; authors' personal observation in 2012; Simpson, 2012 [2012 data]; Cocker, 2014 [2011 data])¹⁰ indicates that the real farmgate price (measured in 2005 United States dollars¹¹) in Ghana nearly doubled between 2005 and 2012. However, four of the five regions (except for Ashanti) that the authors' surveyed experienced declined farmed tilapia prices from 2011 to 2013. The authors speculate that cheaper tilapia from over the border with Côte d'Ivoire might exert a downward pressure on prices in the Western and parts of the Brong Ahafo regions. Of the regions studied, the Western region shares the most extensive border with Côte d'Ivoire, a country that seems to be stepping up its imports of (cheaper) frozen tilapia from other countries (e.g. China) during the study period (see Table 1). A forum posting in SARNISSA¹²

¹⁰ The actual years when these prices were observed are often earlier than the citation dates.

¹¹ The real price of tilapia (measured in 2005 United States dollars) in a certain year is calculated by adjusting the tilapia price in that year by the inflation rate in Ghana relative to year 2005 and then converting the result into United States dollars based on the GHC-USD exchange rate in 2005.

¹² By N. Murali on 4 March 2014.

indicated that the farmgate price of whole round tilapia was US\$2.33–US\$2.53/kg (i.e. GHC 6.2–6.7) in 2014, which was approximately half the price of tilapia in 2009 in real terms.

In Ghana, fresh or live tilapia is more expensive than processed fish in terms of live weight equivalent because of the high demand for fresh tilapia. Smoked fish is more expensive than salted or dried fish because it is considered more “fresh”. Antwi-Asare and Abbey (2011) reported that the average prices of fresh and smoked tilapia were GHC 4.58/kg and GHC 6.55/kg, respectively, in 2011. While the smoked tilapia was more expensive in dry weight than fresh tilapia in wet weight, it could actually be cheaper in terms of wet weight equivalent. Indeed, some traders at the Galilea market, near Kasoa in the Greater Accra region, reported that salted and dried tilapia were sold for half the price of fresh fish (authors’ unpublished data).

3. TILAPIA FARMING: ECONOMIC AND SOCIAL PERFORMANCE

3.1 Business structure and farming and post-harvest systems

The main tilapia farming systems in Ghana are cages and ponds with a few documented pen systems (Nunoo, Asamoah and Osei-Asare, 2012; Anane-Taabeah, 2012; Fisheries Commission, 2012). Cage farming, practiced primarily on Lake Volta, ranges from small with one or two cages to large commercial farms with hundreds of cages (Plate 10). For cage farms, typical cage configurations are 2–5 m deep and 4 m × 6 m, 6 m × 6 m, or 5 m × 5 m area (Ofori *et al.*, 2010; Simpson, 2012). Yet many other variations have been reported. Ofori *et al.* (2009) estimated the cost of renting a single 4 m × 6 m × 2 m cage at US\$194 per year based on a four-year amortization.

Most of the pond farms (up to 90 percent) have one to two ponds with an average area of 400–800 m². Larger pond farms can have a total pond area reaching 2 ha or more with an individual pond size up to 5 000 m² (Plate 13). While there is a wide variation of pond sizes, Fynn (2014) found that the most common pond size was 300 m².

Plate 13

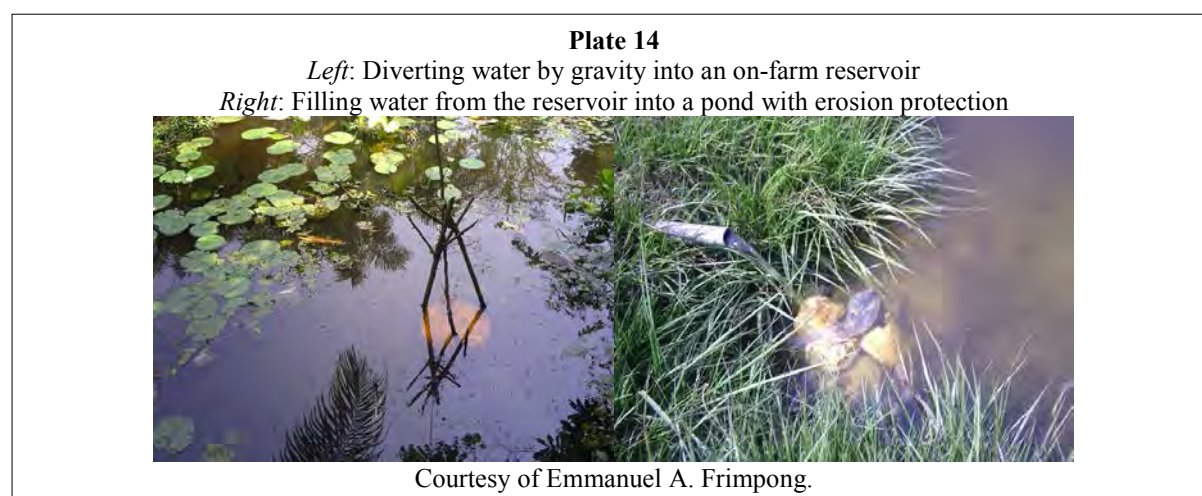
Top: Grow-out ponds (about 0.5 ha) in Gyan Fosu Farms
Bottom left: Tilapia and catfish polyculture ponds (1 ha) in Kumah Farms
Bottom right: Small hatchery ponds constructed with stable levees and connected to a drainage ditch in Bosomtwi Integrated Aqualife Village



Courtesy of Emmanuel A. Frimpong.

A survey of 20 grow-out ponds of various sizes across five farms revealed very shallow water depth of ponds averaging 0.5 m, with maximum depth of 0.7–1.0 m (Frimpong *et al.*, 2014). Larger ponds tend to be deeper. In combination with survey data, Fynn (2014) showed a strong relationship between average pond depth on a farm and farmer-reported annual productivity; productivity increased from 1 000 kg/ha per year in ponds averaging 0.4 m water depth to over 5 000 kg/ha year in ponds averaging about 1 m deep.

On average, about 80 percent of ponds are manually constructed in most of the regions (Asmah, 2008; Nunoo, Asamoah and Osei-Asare, 2012), with the Greater Accra region being the exception where 83 percent of ponds are mechanically constructed (Nunoo, Asamoah and Osei-Asare, 2012). The contrast between Accra and other regions is a clear indication that equipment availability is a key factor determining the choice between manual and mechanical pond construction. Nearly all farms are located near streams where ponds can fill readily with groundwater or by gravitational flow from the stream with supplementary pumping (Plate 14).



Farmland in a representative region, the Ashanti region, costs an estimated US\$3 640/ha and US\$2.40/m² for pond construction.¹³ The vast majority of fish farms in Ghana are fully or partially self-financed (Anane-Tabbeah, 2012; Nunoo, Asamoah and Osei-Asare, 2012). A few large-scale, industrial aquaculture projects are foreign investments originating primarily from Asia, Europe and the United States of America. Foreign investors have been attracted to aquaculture in Ghana by incentives such as tax breaks on imported farm inputs (e.g. feed) and the government's drive to dramatically increase domestic fish production.

Loans from local banks are not readily accessible because farmers are unable to provide the required collateral (Anane-Taabeah *et al.*, 2011). Cage farms essentially rent the water from the government, which does not meet the requirements for collateral. For pond farms, the vast majority own small and marginal land parcels, the value of which is not considered significant by most large banks.

When available, the market interest rates of bank loans are usually too expensive for most farmers (Ansah, 2014). Banks' familiarity with fish farming is low. Aquaculture is still perceived by the banking sector as a high-risk business with no comprehensive insurance options available to farmers.

The authors estimated that cage culture accounted for about 95 percent or more of the tilapia production reported by the Fisheries Commission of Ghana in 2012. Almost all cage farmers reported growing the improved strain (Akosombo) of *Oreochromis niloticus* developed by the Aquaculture Research and Development Centre with technical assistance from WorldFish (Badjeck and Delaporte, 2012). There is a general sense that farmers were not satisfied with the growth and hardiness of the Akosombo strain. Some farms were involved in activities trying to improve it or import better strains.

¹³ Personal communication by N. Siaw from Kumah Farms.

Pressure on the government to approve importation of the genetically improved farmed tilapia (GIFT) strain is increasingly high.

Fish farming in Ghana is not strongly affected by seasonality because temperatures are relatively stable at around 26 °C throughout the year with only mild decreases in temperature during the peak of the major rainy season (June and July).

Cage farmers grow tilapia for approximately 6–7 months to attain market sizes of 400–500 grams (Anane-Taabeah, Quagraine and Amisah, 2015), whereas it usually takes pond farmers 8–9 months to obtain 250–300 grams. Some pond farmers may grow their crops for up to two years (Nunoo, Asamoah and Osei-Asare, 2012). However, using monosex (all male) fingerlings with good feeds and feeding practices, some farmers can routinely harvest 300–350 gram tilapia in five months from 10 to 20 gram stocking size.

Tilapia fingerlings cost US\$0.12–US\$0.20/fish in the 2–5 gram size range (Ofori *et al.*, 2009, 2010; Antwi-Asare and Abbey, 2011). Pond farmers throughout the country grow a wide range of wild, mixed and unknown strains of *Oreochromis niloticus* due to inaccessibility of fingerlings or efforts by various farms to “develop their own strains” to improve the Akosombo strain.

Hormonally sex-reversed fingerlings are supplied by various hatcheries with fingerling sizes targeted primarily at cage farms. Over the years, the size of fingerlings sold has decreased from 5 grams to 2 grams and less. Besides the high demand for fingerlings, another driving force behind this trend is the reportedly high mortality in transporting large sizes of the Akosombo strain fingerlings with more developed spiny fins.

Because of the absence of a nursery component of the tilapia value chain in Ghana (Anane-Taabeah, Quagraine and Amisah, 2015), it is assumed that farmers who purchase smaller fingerlings will raise fingerlings to the desired size before stocking in outgrowing ponds. Experience indicates that this is usually not done, and high mortality and poor growth have often resulted from stocking fingerlings or fry of inappropriate size both in cage and pond systems. The survival rates of fingerlings in ponds varied significantly and ranged from 3.2 to 85.7 percent, with a median and mean of 41.6 percent and 38.1 percent, respectively (Asmah, 2008). The wide variability in survival is expected given the range of practices, such as stocking densities and sources of fingerlings or fry. However, these data were obtained through surveys, and no experimental determination of survival during transportation or in ponds has been documented. Survival in cages has been reported to be 70–80 percent (Ofori *et al.*, 2009), with a few outlying numbers of low survival also reported. For example, Ofori *et al.* (2009, 2010) recorded 30 percent survival when handling practices were poor during fingerling transport.

While most cage farms in Ghana use “monosex” tilapia fingerlings, pond farms generally lack confidence in the sex-reversal technology used by their source hatcheries and control unintended propagation by polyculture of tilapia with catfish. Most of the pond farms are too far from the most reliable hatcheries for supply of sex-reversed tilapia, and roads are generally in poor condition so that transportation over long distances entail high costs and significant risks of losing fingerlings to stress-induced mortality.

As a result of inadequate supplies of high-quality fingerlings, substandard fingerlings are frequently sold to farmers, and various inefficient and technically flawed approaches are taken by pond farmers to produce their own fingerlings. Regardless of the source of fingerlings, stocking density in ponds varies widely from 2/m² (authors’ personal survey) to 17/m² (Nunoo, Asamoah and Osei-Asare, 2012; Rao, Perrino and Barreras, 2012). Considering that ponds may be only 0.5 m deep (Frimpong *et al.*, 2014), the stocking densities could reach 30/m³.

The reported stocking density in cages ranges from 40/m³ to 200/m³ (Ofori *et al.*, 2010; Rao, Perrino and Barreras, 2012; Simpson, 2012). Considering the survival of 70–80 percent puts the average

effective stocking density in cages at about 100–130/m³. Ofori *et al.* (2009) suggested that density-dependent mortality sets in when stocking density exceeds 70/m³. The risk of mortality would also depend on other factors such as the size of fish stocked, temperature and dissolved oxygen conditions.

Current cage farms rely exclusively on commercial floating feeds imported or locally manufactured, whereas pond farms exhibit a significant variation in feeding practices. Farm-made sinking mixtures of rice, wheat and maize bran, and even groundnut peels, are used to feed the fish (Awity, 2013). Some of the mixtures are pelleted on-farm with the total cost of on-farm feed production approximating US\$0.25–US\$0.30 per kg (Y. Ansah and E. A. Frimpong, unpublished data). A few large pond farms use manufactured floating feed consistently through the production cycle. The lowest protein content of most common tilapia feeds on the market is about 30 percent crude protein, which is targeted at cage farming of tilapia during post-juvenile growth and is not that profitable for pond farmers to use. Based on the recommendation of feed manufacturers and suppliers (e.g. Raanan Fish Feed, Western Africa), feeding rations for tilapia in cages are from 10 percent of average body weight (ABW) at 2 grams to 1.5 percent of ABW at 500 grams in the temperature range of 27–28 °C.

When applied, supplementary feeding in grow-out ponds is done manually by broadcasting, commonly twice a day (Awity, 2013), at a total of 1–5 percent ABW/day (Plate 15). On the other hand, most pond farmers apply chemical fertilizers and/or manures until a plankton bloom is established in their ponds. Chemical fertilizers commonly used include monoammonium phosphate applied at 20 kg/ha at the cost of US\$2.40/kg and urea applied at 30 kg/ha at the cost of US\$0.40/kg. The most commonly used manure are from poultry, sheep, goat and swine (Nunoo, Asamoah and Osei-Asare, 2012). Of these, chicken manure is the most typical, and the recommended rate is 50 kg/ha during pond drying and after liming. The cost of chicken manure is US\$0.06/kg.¹⁴

Plate 15

Left: A farmer demonstrating how to use a “gong-gong” to alert fish for feeding

Right: A farmer demonstrating manual feeding of pellets up to satiation



Courtesy of Emmanuel A. Frimpong.

The use of aeration in production ponds is uncommon to non-existent for two reasons: (i) the level of intensity of input use is generally still low in Ghana, making aeration unnecessary; and (ii) electricity supply in the country is unreliable so that it is impractical and costly to plan a production system that depends on constant electricity supply, especially in rural areas.

As a result of the wide variation in practices, survival of fingerlings and reported production and productivity of farms vary widely, especially among pond farms (Plate 16). Asmah (2008) reported productivities of 80–10 839 kg/ha per year with a mean of 2 952 kg/ha per year and a median of 2 414 kg/ha per year. Asmah (2008) observed that only about 10 percent of farms attained the yields in the higher end of the range.

In recent on-farm experiments with the Akosombo strain of Nile tilapia and supplementary feeding of 30 percent crude protein commercial feed at 1–4 percent ABW, the authors observed yields up to

¹⁴ Personal communication by D. Adjei-Boateng from Kwame Nkrumah University of Science and Technology.

14 000 kg/ha per year in deeper ponds (up to 1 m water depth). The authors' personal data showed that the lowest productivity, in the range of 1 000–3 000 kg/ha per year, were from shallow ponds fed feeds similar to the farm-made sinking feed (32 percent crude protein), and where in-pond breeding was highest in spite of starting out with what was supposed to be all-male fingerlings obtained from a private hatchery.



The productivity of cage culture is in the range of 37 kg/m³ to 56 kg/m³ under average mortalities and high stocking density (Ofori *et al.*, 2010; Simpson, 2012). Farmers are aware of the stocking density-survival rate relationship and sometimes target lower productivity (e.g. 28–40 kg/m³) by stocking less fish (Rao, Perrino and Barreras, 2012; N. Murali, SARNISSA, 10 March 2014).

Feed conversion ratios (FCRs) that have been reported for cage culture are 1.6–1.7. More recent reports¹⁵ suggest FCRs decreasing to 1.2–1.4 with a new brand of feed and better feed budgeting and management. Higher FCRs (2.5–3.5) were reported by Ofori *et al.* (2009, 2010) from cages with 30 percent crude protein feed,

where the higher FCRs were attributed to cages with high mortality.

FCRs reported from ponds vary greatly depending on the type of feed. Asmah (2008) calculated pond mean FCRs of cereal bran mixed with fishmeal to be 4.6 (\pm 1.5) and that of cereal bran only 5.9 (\pm 0.8). Frimpong *et al.* (2014) recorded an average FCR of 2.1 from ponds with commercial floating feed and 5.4 with the farm-made sinking feed, similar to that calculated by Asmah (2008). The cited studies further suggested that FCRs could be improved by decreasing experimental feeding rates that may have been too high. Frimpong *et al.* (2014) observed that use of farm-made sinking feed in powder form caused great wastage leading to much worse FCRs.

Pond harvesting is done manually by seining, often with partial or complete draining of the pond in the harvesting process depending on the amount of fish desired. To harvest tilapia in cages, anchor weights are first removed with tractors, and then boats are used to haul the cage to shore for total harvest (Rao, Perrino and Barreras, 2012).

As discussed in the value-chain section, the post-harvest part of the chain is relatively simple. Tilapia sold as fillets through supermarkets is a small component of the market in Ghana, catering primarily to a small affluent group of consumers. The value chain has no significant processor component (Hamenoo, 2011). Except for the largest cage farms that have appropriate cold-chain networks to freeze large volumes of fish for later sales, most farmers sell their fish right after harvest. Fish is sold whole and fresh on order. Retailers, mostly women, may process fish by scaling and gutting, and then selling the fresh fish on ice (Simpson, 2012). Further processing of fish such as smoking, salting and drying, and frying only occur on a significant scale when fish cannot be sold immediately, making the processes more of a means of preservation.

3.2 Economic performance

The economic performance of tilapia farming in Ghana has been analysed by a number of studies spanning from 2005 to 2013, including Kaliba *et al.* (2007), Asmah (2008), Nunoo, Asamoah and Osei-Asare (2012), Ofori *et al.* (2009), Cobbina (2010), Anane-Taabeah, Quagraine and Amisah

¹⁵ Personal communication by N. Murali via SARNISSA, 4 March 2014.

(2015), and Frimpong and Ansah (unpublished data). Most of the studies analysed multiple scenarios representing some of the typical culture systems encountered in the country, and most analyses were based on enterprise budgets. Asmah (2008) and Cobbina (2010) also included benefit-cost analyses. With the exception of Ofori *et al.* (2009) and Nunoo, Asamoah and Osei-Asare (2012), which analysed cage and pen systems, respectively, most published work on economic analysis is based on pond systems. Key results of the studies are summarized in Table 4 and Table 5. Effort was made to place each study in the actual year of data collection, which often differed from the publication date, in some cases by as much as four years.

Production systems covered in Table 4 and Table 5 range widely, from small farms of a single 0.1 ha pond (or several small ponds with that total area) to relatively large farms of up to 2 ha total pond area. These farms may practice monoculture of tilapia (*Oreochromis niloticus*) or polyculture mainly with catfish (*Clarias gariepinus*). The monoculture of all-male tilapia in ponds was of limited applicability on a large scale because of the limited success rate of sex reversal. Thus, systems characterized as all-male polyculture and mixed-sex polyculture are practically often indistinguishable, and catfish in the culture system is a secondary production objective in terms of revenue determination. The length of production ranges from six months to one year, although some extensive systems go for longer periods without harvests. Some of the lengths of production in Tables 4 and 5 are inferred by the authors from other parameters, as they are not clearly stated in the sources. The analysis reported for a single experimental cage system was based on a 48 m³ cage (4 m × 6 m × 2 m dimension) with a seven-month length of production and fed sinking or floating feed. Many of these specifications are expected to have changed greatly since the study was conducted in 2008 and published in 2009. The source of the data used in the pond studies ranges from complete simulation to surveys and on-farm experiments or a combination of both.

The studies summarized in Table 4 and Table 5 used different assumptions on components of the farm budget, some of which are not explicit or may change significantly through time. Major variable cost components distinctly reported in the studies were feed and fingerlings. Labour was often lumped with other variable costs and could not be accurately separated, but could be assumed to be most (70–80 percent) of the remaining variable cost after accounting for feed and fingerlings. Labour utilization in both pond and cage aquaculture in Ghana, including the commitment of the proprietor's time, may be full time or part time. Family labour is widely utilized, similar to crop farming. Hired labour is used for activities, such as culture facility preparation and maintenance, stocking, feeding and harvesting. Pond farmers employ a median 2–2.5 full-time employees, some of whom may be family labour not paid the full labour rate. Large cage farms have a corporate structure and employ people with all levels up to a master's level of university education for different purposes. Part-time daily labour is used for most labour-intensive work across all farm types and paid a daily rate of about US\$10. Family labour is often not valued when farmers determine the profitability of their business. Consequently, most of the smallest farms are not profitable when benefit-cost analysis accounts for the opportunity cost of family labour, even when using just the national minimum daily wage rate, currently at about US\$2/day (e.g. Kaliba *et al.*, 2007; Asmah, 2008; Cobbina, 2010; Nunoo, Asamoah and Osei-Asare, 2012; Anane-Taabeah, Quagraine and Amisah, 2015).

Both cage and pond aquaculture could be profitable in Ghana, but the profitability tends to be positively correlated with farm size. It appeared that technical efficiency tends to increase with farm size (Onumah and Acquah, 2010). However, financial analysis of small farms may still indicate positive cash flows because the labour of family and owners is often not fully counted (Kassam, 2013).

According to Table 4, relatively large pond farms (0.20–2.0 ha) had a benefit-cost ratio (BCR) of 1.1–7.9; the ratio appeared to increase with farm size and intensity of operation. For the same range of farm sizes, the internal rate of return (IRR) ranged from 32 percent to 105 percent; the payback period was 1–4 years. On these same performance metrics, small farms with a pond area of around 0.1 ha or less had relatively low BCR (around 1 or less), a low IRR (less than 5 or negative), and a long payback period (over 10 years).

Among farms with more than a 0.2 ha pond area, Asmah (2008) examined a variety of low-input systems (cases 5–10 in Table 5 with a relatively low share of feed in total cost) and found them generally unprofitable. This result underscores the importance of feed as a driver of both cost and profit. Thus, it appears that profitability of pond farms is a function of both farm size and intensity of management, and these two factors are positively correlated.

Excluding for the low-input farms, all cases in Table 5 with a pond size of more than 0.2 ha were profitable. In these cases, feed cost averaged about 50 percent of the total cost and fingerlings about 20 percent. The cost of feed and fingerlings as percent of variable cost could not be determined reliably because many studies did not provide sufficient detail. However, based on the authors' data, the percent of feed as variable cost would be about 60 percent for pond farms using commercial feeds for grow-out. The profit margin of these farms ranged from 1 percent (case 18) to 57 percent (case 14). The break-even price ranged from US\$0.78/kg (case 14) to US\$4.73/kg (case 17).

Commercial feeds were used in all the cases in Table 5, except case 18 where farm-made sinking feed was used. The profitability of case 18 was the lowest, bordering on negative profitability with 1 percent of profit margin. This highlights the importance of investing in complete, supplementary feeds in addition to expanding the size of the farm.

The results of case 1–4 (Table 5) examined in Kaliba *et al.* (2007) suggest that all-male monoculture tends to be more profitable than mixed-sex polyculture. Indeed, mixed-sex tilapia farming is not a production system of choice, but a result of inadequate supply and the lack of access to high-quality sex-reversed fingerlings (Rao, Perrino and Barreras, 2012).

The example of pen culture (case 15) studied in Nunoo, Asamoah and Osei-Asare (2012) was marginally profitable, with a profit margin of 7 percent (Table 5). The cage culture example (case 19) examined in Ofori *et al.* (2009) indicated profitability, yet the profit margin (20 percent) was lower than most of the pond systems in Table 5 using complete supplementary feed.

Cage culture in Ghana today is completely dependent on floating feeds. The technical performance of cage tilapia farming in Ghana (e.g. survival rates, FCRs and yields) has improved, but the cost of production has also gone up.¹⁶ Based on information provided by the tilapia cage farm manager mentioned in footnote 9, the production costs of 1 kg of tilapia at an average body weight of 380–400 grams amounted to GHC 0.60 for fingerlings, GHC 4.2–4.8 for feed, and GHC 0.5–1.5 for overhead costs such as salaries and maintenance; the overall production cost was at the range of GHC 5.5–6.2 per kg of tilapia. This indicates that the feed cost accounted for about 70–80 percent of the production cost and fingerling cost of 10–11 percent. With the average farmgate price for tilapia at about GHC 6.2–6.7 per kg, cage tilapia farming in Ghana appeared to have a thin profit margin of 8 percent. Such anecdotal evidence provides only limited information about the profitability of cage tilapia farming in Ghana; a more current, rigorous analysis of the economic performance of cage farming is needed.

¹⁶ Personal communication by N. Murali via SARNISSA, 4 March 2014.

Table 4: Benefit-cost analysis of tilapia farming in Ghana

Case no.	Pond area (ha)	Fingerlings	Length of production (years)	Annual discount rate (%)	Investment time horizon (years)	Net present value (US\$)	Payback period (years)	Internal rate of return (%)	Benefit-cost ratio
I	0.10	All-male, monoculture	0.58	15	10.5	-3 039	10.5	10.5	0.94
II	0.20	All-male, monoculture	0.58	15	10.5	17 036	3.5	32	1.18
III	0.11	Mixed-sex, polyculture	1.00	13	10.0	< 0	88	< 0	1
IV	0.02	Mixed-sex, polyculture	1.00	13	10.0	< 0	14	4	2.5
V	0.66	Mixed-sex, polyculture	1.00	13	10.0	< 0	n.a.	< 0	< 1
VI	0.47	Mixed-sex, polyculture	1.00	13	10.0	< 0	n.a.	< 0	< 1
VII	0.25	Mixed-sex, polyculture	1.00	13	10.0	< 0	n.a.	< 0	< 1
VIII	1.01	Mixed-sex, polyculture	1.00	13	10.0	6 143	4	35	2
IX	2.01	Mixed-sex, polyculture	1.00	13	10.0	45 210	2	62	4.1
X	1.97	Mixed-sex, polyculture	1.00	13	10.0	246 248	1	105	7.9

Source: Authors' summary of data from Cobbina (2010) for case I and II and from Asmah (2008) for case III to X.

Note: n.a. = not applicable.

Table 5: Enterprise budget analysis of tilapia farming in Ghana

Case no.	Year	Farming system *		Fingerlings	Length of production (year)	Annual yield (kg/ha)	Annual profit		Share of feed in total cost (%)	Share of fingerling in total cost (%)	Profit margin (%)	Break-even price (US\$/kg)
		Pond/pen (ha)	Cage (m ³)				US\$/ha	US\$/m ³				
1	2005	0.20		Mixed-sex; polyculture	1.00	3 640	1 215		58	21	26	0.96
2	2005	0.20		All-male; monoculture	1.00	4 395	3 320		62	17	46	0.89
3	2005	0.40		Mixed-sex; polyculture	1.00	3 613	1 208		58	21	26	0.96
4	2005	0.40		All-male; monoculture	1.00	4 398	3 340		63	17	46	0.88
5	2006	0.11		Mixed-sex; polyculture	1.00	2 284	1 500		31	10	4	1.70
6	2006	0.66		Mixed-sex; polyculture	1.00	1 436	< 0		12	8	n.a.	2.11
7	2006	0.47		Mixed-sex; polyculture	1.00	1 787	< 0		9	24	n.a.	2.59
8	2006	0.25		Mixed-sex; polyculture	1.00	1 518	< 0		14	18	n.a.	2.40
9	2006	1.01		Mixed-sex; polyculture	1.00	4 500	3 447		23	16	37	1.31
10	2006	2.01		Mixed-sex; polyculture	1.00	10 000	6 181		18	14	60	0.84
11	2008	0.12		Mixed-sex; polyculture	1.00	15 400	5 400		16	9	17	1.71
12	2008	0.04		Mixed-sex; polyculture	1.00	18 000	< 0		n.a.	n.a.	n.a.	5.56
13	2008	0.20		Mixed-sex; polyculture	1.00	13 100	4 400		n.a.	n.a.	14	1.98
14	2008	0.40		Mixed-sex; polyculture	1.00	28 300	29 300		n.a.	n.a.	57	0.78
15	2008	0.65		Mixed-sex; polyculture	1.00	24 200	360		4	33	7	1.87
16	2009	0.20		All-male	0.58	34 714	42 823		79	8	41	1.77
17	2013	0.48		All-male	0.50	33 210	24 704		60	19	14	4.73
18	2013	0.48		All-male	0.50	16 605	517		19	47	1	3.95
19	2009		48	All-male	0.50	n.a.		27	52	26	20	2.13

Sources: Authors' calculation based on data from Kaliba *et al.* (2007) for cases 1–4; Asmah (2008) for cases 5–10; Nunoo *et al.* (2012) for cases 11–15; Cobbina (2010) for case 16; Frimpong and Ansah (unpublished data) for cases 17–18; and Ofori *et al.* (2009) for case 19.

*Case 15 is pen culture, case 19 is cage culture, and all other cases are pond culture.

Note: n.a. = not applicable or not available.

The pressure inflicted by the continuing depreciation of the Ghana cedi against the United States dollar on cage farming in Ghana through imported feeds or feed ingredients has been noted by many experts.¹⁷ With the break-even price of about US\$1.10 for pond-raised tilapia from the current analysis and at least US\$2 for cage-raised tilapia (see also Hamenoo, 2011), it appears that tilapia could be produced more cheaply in ponds with less dependence on feed that is now widely available yet relatively expensive.

The future of the economic performance of fish farming will depend on the ability to sustain a reduced market price for tilapia produced locally. A long-term reduction in feed prices can be hoped for, but there is no government policy that can readily accomplish that in the free market. On the other hand, enhancing pond aquaculture productivity to encourage more pond production, which has been a neglected component of aquaculture development in Ghana to date, is feasible and necessary at this juncture. Options for reducing the feed cost component of a pond farm budget may include improved feeding strategies, such as alternate-day feeding, feeding daily at half ration, and development of lower protein content (e.g. 25 percent crude protein) feed specifically for pond grow-out of tilapia. The government could provide incentives to feed manufacturers for the production of low protein feed in a concerted effort that would demonstrate the benefits of this kind of feed in pond culture and encourage its widespread adoption by pond tilapia farmers.

3.3 Social performance

The social performance of tilapia farming in Ghana is an area that has not received sufficient attention historically because until recently aquaculture as a whole has not contributed significantly to domestic fish production. The fisheries sector as a whole was widely cited to contribute only 3–5 percent of the agriculture component of the total GDP (e.g. Fisheries Commission, 2012, in the Ghana National Aquaculture Development Plan). WorldFish (2011) suggested that the fisheries production value in Ghana is equal to nearly 20 percent of the country's agricultural GDP and 7 percent of its total GDP. Fisheries statistics have been rarely separated from the general agriculture sector. Among some of the most fisheries dependent countries, Ghana ranked sixth in overall fisheries dependency (combining nutritional, macroeconomic and employment dependence) and third on nutritional dependency after Maldives and Cambodia (WorldFish, 2011). However, the socio-economic contributions of aquaculture are usually included in the contributions of fisheries as a whole and rarely measured distinctly.

Amidst many caveats about the reliability of data and model assumptions, Kassam (2013) estimated the regional multiplier effect of small-scale pond farming in the Ashanti region of Ghana at 2.3–2.6 (implying that every dollar generated from pond farming would induce US\$1.3–\$1.6 of additional income in other sectors in the region) and a national (both direct and indirect) multiplier effect of 4.3–5.0. Comparatively, small- and medium-scale cage farms in the Eastern region were estimated to have a regional multiplier effect of 1.5–1.6 and a national multiplier effect of 2.1–2.3. Similar estimates were not available for large cage farms due to unavailability of budget and expenditure data, but it was expected that these would have a lower multiplier effect because most of the large farms were foreign owned and employed significant expatriate labour (Kassam, 2013).

With rapid growth in aquaculture over the past few years and the creation of a separate Ministry of Fisheries and Aquaculture Development, a significant improvement is expected in the reporting of public- and private-sector aquaculture statistics and social performance of the sector in the years ahead. Thus, with the exception of a few country-level numbers, which may be outdated, or the validity of which is sometimes questionable, the analysis of the social performance of aquaculture in this paper would be based on a few recent case studies.

¹⁷ Including Mark Amechi, the CEO of Tropo Farms, a large producer of tilapia in Ghana (SARNISSA, 22 February 2014); Jacob Ainoo-Ansah, the chairman of the Ghana Aquaculture Association (the *Ghana Chronicle*, 10 December 2013); and Naga Murali, the manager of Volta Breems Ltd, a tilapia hatchery and cage-based production business in Ghana (SARNISSA, 4 March 2014).

Food and nutrition security

The importance of fish in the nutrition of Ghanaians and the preference for tilapia over many species is well documented. According to FAO statistics,¹⁸ per capita fish consumption in Ghana in 2011 was 27 kg/person per year (live weight equivalent), higher than the world average of 19 kg/person per year and the average of 11 kg/person per year in Africa. WorldFish (2011) cited the WorldFish/FAO “Big Numbers Project” and the QUEST-Fish project that showed that 60–73 percent of animal protein in the Ghanaian diet is fish. Specifically for tilapia, Asmah (2008) studied the tilapia consumption patterns in four regions of the country (Ashanti, Eastern, Greater Accra and Volta) and reported that about 90 percent of households consume tilapia regularly or occasionally. The authors calculated from Asmah (2008) that per capita consumption of tilapia ranged from 9.0 to 20.5 kg per year, with the Volta region recording the highest rate and the Ashanti region recording the least. On the aggregate, Asmah (2008) deduced that 74 444 tonnes of tilapia were consumed in Ghana annually at the time of the study. This estimate agrees with Kaunda *et al.* (2010, as cited in the Kassam, 2013, estimate of 60 000–120 000 tonnes annual demand for tilapia consumption in Ghana.

The livelihood and nutrition impacts of fish farming to households appear to differ among poor and non-poor households. Poor fish farming households ate more fish than non-poor fish farming households because the latter tended to substitute meat (associated with higher social prestige in Ghana) for fish. Thus, fish plays a significant role in rural household food security. However, among all groups surveyed, including non-fish farming households, food intake measured by simple food counts and food consumption scores was found to be high, although Kassam (2013) inferred that fish farming households had slightly better food adequacy. More work, however, remains to be done in Ghana to promote farmed tilapia consumption. The preference for wild fish over farmed fish has been consistently reported (Anane-Taabeah, 2008; Asmah, 2008; Darko, 2011).

Employment

At the national level, the fisheries sector is estimated to employ about 10 percent of the population (NFDS, 2009). This estimate is largely for the fisheries sector as a whole, and most people engaged in the sector would also be employed in other sectors, leading to the tendency to overestimate the contribution of the sector to employment. Given that aquaculture contributed approximately 4 percent of total fish consumed in Ghana in 2012 (Ainoo-Ansah, 2013) and assuming that the fisheries and aquaculture sector employments are proportional to domestic fish consumption, the optimistic number of people employed by fish farming full time or part time in the entire value chain is about 100 000. A majority of these people will earn additional income from other jobs. Other occupations that fish farmers could be involved in include crop farming, artisanal fishing, and civil servants and traders. Fish farming is often the secondary or tertiary occupation for the majority of farmers (Anane-Taabeah, 2012; Nunoo, Asamoah and Osei-Asare, 2012; Kassam, 2013).

Livelihood

Fish farming households in the Ashanti region of Ghana, both poor and non-poor, derived about 8 percent of their household income from fish farming (Kassam, 2013). Capture fisheries still seem more attractive to fishers than aquaculture. Fishers who lacked savings had difficulty in accessing credit to run their business; those who were newer to marine fishing were more willing to consider integrating fish farming (Anning *et al.*, 2012).

Kassam (2013) reported that 85 percent of rural Ghanaian respondents to a survey on fish farming and poverty claimed that low-income fish farmers usually earned less profit than high-income fish farmers. Among rural households in the Ashanti region, Kassam (2013) reported over 30 percent higher average household income for fish farmers than non-fish farmers. However, there was no significant difference in per capita household income among these groups. Non-poor fish farmer households in the study were slightly larger on average (8.1 persons) compared with non-poor, non-fish farmer households (7.3 persons).

¹⁸ FAO food balance sheet available at <http://faostat.fao.org/site/368/default.aspx#ancor>.

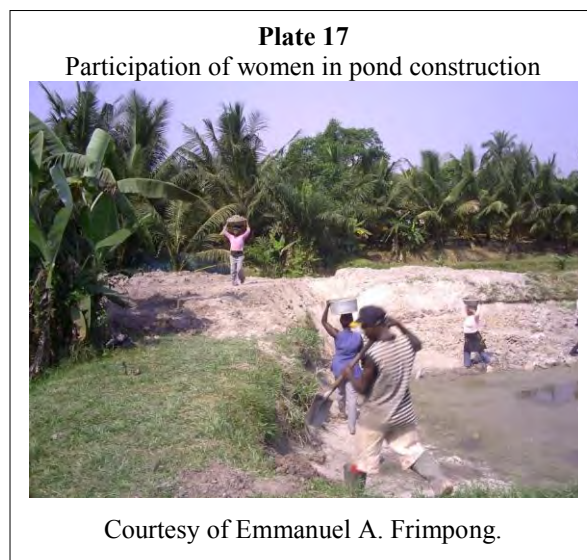
Asmah (2009) recounted specific benefits of cage farm workers to include regular incomes, free meals at work, informal interest-free loans given by employers, employer contributions to social security and health-care coverage, and the education gained through their employment. Traders also gained income and employed temporary help to clean fish for selling.

Women and children

Most of the major production activities in aquaculture, such as pond preparation, input procurement, application of feeds or fertilizers, and harvesting, involve mainly men (Nunoo, Asamoah and Osei-Asare, 2012). Women accounted for 11 percent of the workforce in the two cage farms studied in Asmah (2009). Women who are formally employed on fish farms tend to be educated and could occupy both administrative (e.g. clerical) and technical (e.g. hatchery manager) positions.

In Ghana, only about 10 percent of fish farms have been solely owned by women (Asmah, 2008; Nunoo, Asamoah and Osei-Asare, 2012; Ansah, 2014). However, sole farm ownership is inadequate to assess gender impacts of tilapia farming. Women are traditionally heavily involved in the labour force during pond construction and in the post-harvest (processing and marketing) components of the tilapia value chain (Plate 17). Almost all fish processors and sellers in the open fish market are women. In addition, there is a significant yet inconsistently documented joint ownership of farms and ancillary enterprises (e.g. hatcheries, feed and fertilizer retail stores, and restaurants) by husbands and wives; in which case, husbands as the heads of households are traditionally identified as owners (Asmah, 2008).

The involvement of children in aquaculture in Ghana is not significant, though some children may help their parents in the “family trade”, similar to children with parents who farm other crops. The authors are aware of no reported instances of children forgoing school or earning their living on fish farming and related activities. Thus, it appears that as of 2013 child labour is not a salient issue in fish farming in Ghana.



Social amenity

The case study by Kassam (2013) on pond fish farmers did not find strong evidence that fish farming helped improve households' access to infrastructure, transport or communication facilities. However, Asmah (2009) found that 30 percent of staff working on two large cage farms were from the immediate local communities. Ancillary enterprises such as ice production, public transportation and fish oil production tend to surround large-scale fish producing communities (Asmah, 2009; Simpson, 2012). Simpson (2012) noted the significant contribution of cage farming to local employment in Achavanya, Volta region, where there were over 50 farmers (presumably mostly small-scale cage farmers) who were farm managers, drivers,

security personnel and fish cleaners. Also, the establishment of cage farms in rural areas had facilitated the installation of electricity, drinking water wells, telephone lines, and access roads to host communities because the farms need infrastructure to operate (Asmah, 2009; Kassam, 2013).

Communities hosting large cage farms may obtain food fish and fingerlings at discount prices as well as technical assistance for growing fish from cage farms (Asmah, 2009). However, Kassam (2013) suggests that this benefit may not exist for large-scale farms that have structured distribution pathways to move their product directly to urban centres. Simpson (2012) noted a lack of supporting industries, such as input suppliers, service providers and food vendors in Achavanya.

In summary, it seems that the social benefits of tilapia farming vary from community to community, and depend on the scale of production and how long the industry has been established in the host communities.

Environmental impact and public perception

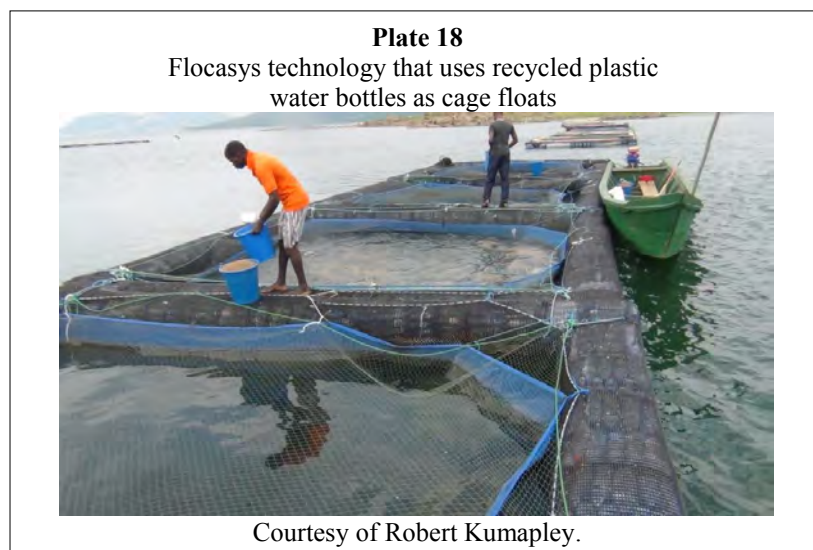
The higher price of wild-caught tilapia compared with cultured tilapia has been attributed partly to the fact that consumers in Ghana generally prefer the taste of wild fish to farmed fish (Anane-Taabeah, 2008; Asmah, 2008; Darko, 2011); they often also perceive farmed tilapia as a less healthy fish (Darko, 2011).

Theft (Anane-Taabeah, 2012; Kassam, 2013) and vandalism (Nunoo, Asamoah and Osei-Asare, 2012), associated especially with pens and cages, suggest that there was public dissatisfaction with the way fish farming is conducted as well as the quality of fish produced from farming.

During a survey in 2010, the authors observed that when a decline in water quality in Lake Volta resulted in massive fish kills in the lake, a common public perception was that the waste produced primarily by cage farms was responsible for the fish deaths. However, instances of fish kills and periodic sharp declines in water quality of portions of Lake Volta are not infrequent occurrences. Kassam (2013) reported the complaints of fishers about loss or reduced livelihood opportunities due to curtailed access to fishing grounds on Lake Volta. Kassam (2013) cited focus groups' concerns about the increasing deterioration of the lake water as a source of domestic water and about the new, large aquaculture farms being established on the lake, which would exacerbate the water quality deterioration. Another reported source of conflict with large cage farms is the destruction of small crop farms in surrounding communities, as new cage farms have been erecting electricity poles to extend power to their farms (Kassam, 2013).

Recent studies (Ansah, Frimpong and Amisah, 2013; Frimpong *et al.*, 2014) found that aquaculture ponds in Ghana tend to produce high nutrient or solid wastes and waterbodies that receive pond effluents tend to have high organic loads – these waters are often the water sources for pond farms.

The tilapia industry in Ghana has taken actions to mitigate the negative environmental impacts of tilapia farming. For example, there has been an effort to recycle plastic water bottles used massively in the construction of cage floats (Plate 18).¹⁹ Educational programmes to help farmers adopt better management practices have also been provided, especially on effluent management and feed use.²⁰



One environmental issue that has received inadequate attention of policymakers in Ghana is the impacts of climate changes on fish farming (e.g. Fisheries Commission, 2012). Ghana was ranked in the medium-risk range by global studies of the potential effect of climate change on fish production (Handisyde *et al.*, 2009). Assessment of climate change vulnerability (e.g. USAID, 2011) has revealed many

¹⁹ Personal communication by R. Kumapley from Laveroff Farms Ltd on the “Flocasys” technology on recycling plastic water bottles used in cage building.

²⁰ In collaboration with the regional fisheries departments, the AquaFish Innovation Lab (formerly AquaFish CRSP) has undertaken extensive education of pond farmers for about five years (2009–2013) and trained about 500 pond farmers in better management practices.

country-specific challenges that the Ministry of Fisheries and Aquaculture Development needs to be actively considering in development planning. However, with the exception of a few regional, donor-driven efforts to address climate change impacts (e.g. Badjeck *et al.*, 2011), climate changes have not been accounted for adequately in aquaculture development planning at the time of this writing.

4. GOVERNANCE AND INSTITUTIONS

Most pond farming in Ghana is conducted on personal or family lands, whereas cage farming is done in public waters with permits from relevant government institutions. There are size thresholds for cage and pond farms to require permits, but these thresholds have not been very clear. Most small-scale farms appeared to be exempted from permit requirements or not actively prosecuted for permit violations. The Fisheries Commission has an updated version of the Aquaculture Regulations of Ghana (Fisheries Regulations, 2010) available for prospective investors and fish farmers.

There are farm size thresholds determining whether an environmental impact assessment is required for establishing aquaculture operations, yet all existing pond farms and most cage farms would fall below the size thresholds. For relatively large farms above the size thresholds, it is unclear whether the process can be strictly followed because most of the impacts are stated only qualitatively in the law. Nevertheless, many aquaculture-related activities, from facility construction to seed production, transport and imports of live fish, fish seed and inputs, are subject to permits issued by the Fisheries Commission (Fisheries Regulation, 2010).

The institutions with regulatory mandates, including issuance of permits for aquaculture-related activities, are the Water Resources Commission, the Environmental Protection Agency (EPA), the Fisheries Commission, and the Ghana Maritime Authority (WRC, 2013). For certain aquaculture operations, an environmental permit from the EPA may be needed before the issuance of an aquaculture permit.

In addition, and where relevant, permit applicants need to obtain consent from any, or all, of the following organizations: Volta River Authority, Ghana Water Company Limited, Ghana Irrigation Development Authority, Water Research Institute, or other institutions as specified on a case-by-case basis (WRC, 2013). Once established, periodic (quarterly to biannual, depending on parameter) monitoring of water quality is required to be reported by the Fisheries Commission to support tracking of environmental performance.

Standard application forms for permits are published as appendixes to the regulations for easy access. There are several regulations in aquaculture in Ghana, but the obvious weakness is inadequate resources or capacity to enforce these regulations, making them largely ineffective.

Farmers' associations are generally splintered and perform little additional functions beyond information exchange. The Ghana Aquaculture Association is the leading voice for fish farmers in the country. Yet, its membership does not encompass all stakeholders in the industry, and the relationship of this national association with numerous small, regional or district associations is unclear. Although regional associations influence price setting at the local scale, large cage farms are the real price setters at the national scale (Kassam, 2013), and tilapia prices are driven more by dynamic market forces than by any individual farm or association.

The government's strategy for the development of aquaculture is encapsulated in the Ghana National Aquaculture Development Plan (GNADP) 2012–2016, which seeks to begin targeted implementation of the national Aquaculture Strategic Framework of 2006. The GNADP was prepared with technical support from FAO. The major targets and highlights of the GNADP are to: (i) increase commercially farmed fish production to 100 000 tonnes by the end of 2016; (ii) increase the market share of farmed fish to 30 percent and the market value to US\$362 million in 2016; (iii) increase the performance of 80 percent of farms in high-priority aquaculture zones by at least 100 percent during the period

2012–2016; (iv) improve environmental sustainability, fish health and fish food safety; and (v) enhance the effectiveness and efficiency of public-sector institutions in aquaculture development, policy-making and regulation (Fisheries Commission, 2012). Although the 2016 production target appears to have been revised down a few times since the publication of the plan, at the time of publication of the GNADP Ghana was actually on track to achieving that target if the current growth rate was sustained a few more years. The accomplishment of other objectives is difficult to evaluate because there are not sufficient data or the baseline and policy targets are not well defined quantitatively.

Besides reduced tariffs on imported equipment and inputs for aquaculture, which primarily favours large-scale aquaculture producers, no specific subsidies are available to fish farmers in Ghana. In light of the fact that the government subsidizes premixed fuel and outboard motors for fishers, aquaculture farmers' associations have frequently called for subsidies on aquaculture activities (Antwi, 2006). The GNADP capitalized on an already existing momentum for the adoption of small- to medium-scale cage culture, which, in spite of a high rate of abandonment (Anane-Taabeah, 2012; Kassam, 2013), continues to account for a significant part of the continuing increase in production because of new entrants and expansion of existing farms. Much of the improvement in institutional efficiency to build government support for the fish farming industry as a whole is lagging, and the inadequacy is masked by the encouraging aquaculture growth driven primarily by the private sector. In light of recurrent economic shocks such as the fluctuation in currency exchange rates that have led to cessation of many small- and medium-scale cage farm operations,²¹ it is questionable whether the growth of aquaculture production in Ghana can be sustained by a few large-scale farms. The government needs to address the vulnerability and fragility of small-scale farms, which includes almost all the pond farms.

5. CHALLENGES AND THE WAY FORWARD

5.1 Issues

Issues perceived by farmers

From the perspective of large cage farmers, the high cost of inputs (especially feed), which leads to high production costs and disadvantageous product prices in the local market, is an emerging problem. Pond farmers also face high input costs, but their lack of access to knowledge of low-cost and efficient production technology appears to be a more pressing issue. From basic pond construction to accessing quality all-male fingerlings of high yielding strains of *Oreochromis niloticus*, the pond farmers' problems are traceable ultimately to inadequate technical or extension support. With the rapid growth in the number of cage farms over the past few years, it is also apparent that many smaller cage farmers enter the business without sufficient knowledge and technical capacity, although the lack of start-up capital is often at the top of the list for those struggling to establish or expand (Anane-Taabeah, 2012).

The problem of inadequate infrastructure, which adversely affects many parts of the value chain, is more acute for pond farmers who are scattered throughout the southern and central parts of the country. Poor infrastructure means that the cost of critical inputs (e.g. feeds and fingerlings) is much higher for these farmers than those in close proximity of cage farming activity. For example, it entails several hundred kilometres of travel over poor roads for farmers in the Western or Brong Ahafo region to obtain large quantities of inputs such as fingerlings and feeds from the Eastern and Greater Accra region, which ultimately increases cost and loss.

Farmers generally perceive that importation of cheap fish from foreign countries posts a major threat to their business. Given that the gap between domestic fish production and total fish requirement in Ghana is still large, the impetus of importing cheaper fish of various varieties to satisfy the domestic

²¹ Personal communication by N. Murali via the SARNISSA, 4 March 2014.

appetite is expected to continue. Increasing domestic production of tilapia could stem imports of fish in general only if the bulk of farmed tilapia can be produced more cheaply than imported fish.

Issues perceived by processors and traders

Processors, most of whom are also traders in the farmed tilapia value chain, generally lack capital and operate largely on credit. Other overarching constraints to this group are poor roads and electricity supply. For processors, traders and distributors, poor infrastructure poses a challenge to maintaining product quality and keeping tilapia prices low. Large producers can afford to move their products from the farm quickly to urban centres because that is where the larger share of the market is and cold chains can be operated relatively more efficiently. Unreliable electricity supply is a major constraint over the lack of independent cold chains in many fish-producing communities.

Issues perceived by consumers

With the expressed preference of wild fish over farmed fish (Anane-Taabeah, 2008; Asmah, 2008; Darko, 2011; Kassam, 2013), it is clear that consumers would need additional education and assurance on the safety and quality of farmed fish in general and tilapia in particular. Taste, oiliness and short shelf-life are the major concerns of consumers and traders of farmed tilapia. The high price of tilapia seems to be another significant reason why poorer consumers would prefer cheaper domestically wild-caught or imported fish over domestically farmed tilapia.

Issues perceived by government

The regional fisheries departments consider themselves inadequately staffed, lacking opportunities for in-service training, and having limited resources such as the means of transportation and equipment to deliver expected technical support to farmers. It is worth noting that aquaculture extension officers in Ghana have only recently been relabelled as such. They used to be generic “fisheries officers”, some of whom do not even have training in aquaculture or extension. In spite of the inadequacy of staff for technical assistance to farmers, it appears that fisheries officers have taken it on themselves to coordinate market linkages between farmers and traders or larger consumers such as restaurants (Kassam, 2013). This is a role that should be played by the private sector if the government provides the right macroeconomic environment.

Issues perceived by the development community

The development community, instead of the Government of Ghana, has largely set the agenda for aquaculture research and development in the country. It appears that the vacuum of self-confidence, created in government officials by a lack of training and resources to perform optimally, has been filled by donors with various and sometimes conflicting agendas.

A prevailing perception in the development community is that aquaculture in Ghana (and in sub-Saharan Africa in general) is not sufficiently commercial and that the cage aquaculture sector is the key to commercialization. However, commercialization of pond aquaculture in Ghana has received insufficient attention from the development community. There is a lack of appreciation in the development community for the notion that countries do not need to choose between large- and small-scale farms (a dichotomy that translates into “cage” versus “ponds” in the case of Ghana), and that both sectors can and should be developed with fervour (Delince and Frimpong, 2012) given that these sectors will likely serve different development objectives (Kassam, 2013). In public forums (SARNISSA, 2010, 2012), there appears to be high demand for increasing the involvement of the private sector to improve the efficiency and effectiveness of aquaculture extension and regulation. In such highly generalized conversations, the peculiar challenges and roles that different scales and systems of fish farming play in any individual country are easily overlooked.

5.2 Future potential and challenges

Expansion, intensification and diversification

The aquaculture production trend indicates a rapid progress toward achieving self-sufficiency in tilapia production. The target of 100 000 tonnes/year by 2016 set in the GNADP could be achievable, even though in more recent references the timeline has been extended to 2018.

Following the current trends, over 95 percent of the targeted production will be tilapia and produced in cages. It is unclear that further intensification of cage farming is needed or warranted, but expansion is clearly under way, with the rate of new entrants into the industry mirroring the trend in production. The slowing market growth and environmental concerns on Lake Volta may exert a significant counterforce to the expansion of cage farming in the near future.

Pond farms on the other hand have large room for sustainable intensification, as most are currently producing well below carrying capacity, and the environmental performance of pond farms in the country appears to be acceptable.

There is room for diversification of pond aquaculture in Ghana. Catfish farming in tanks or ponds could be more profitable than tilapia farming in ponds.²² It is clear that Ghanaians prefer to eat other species of fish than just tilapia. Other species that have been considered for aquaculture and accepted locally as food fish include *Parachanna obscura* (African snakehead), *Heterotis niloticus* (African bonytongue) and various *Chrisychthys* species (Frimpong *et al.*, 2011). The use of irrigation reservoirs for aquaculture is given due consideration in the GNADP and could prove positive for diversification if the government follows through with the plan. The technology for production of new species and in a variety of systems should be pursued as a local research and development priority.

Infrastructure and services

As discussed previously, poor infrastructure, primarily electricity supply and roads, is holding back efficiency in key components of the value chain, especially for small-scale farmers and traders. Poor infrastructure is among the major reasons for high transaction costs in the small-scale pond sector (Kassam, 2013). Improvements in infrastructure will open up business in large parts of the country where pond farming is otherwise highly suitable but currently non-existent or insignificant (Fynn, 2014). Improving roads and electricity supply will reduce the cost of doing business and benefit all parts of the aquaculture value chain in the country.

Education and research and development

The Fisheries Commission of Ghana does not have a research agenda because the government does not fund its own research. This void has been filled by the donor community. Yet donors' priorities are often set top-down and may not always be consistent with one another. The most significant research and development (R&D) activity led by the government (through the Aquaculture Research and Development Centre of the Water Research Institute) is the selective breeding and dissemination of the Akosombo strain of *Oreochromis niloticus* (Attipoe *et al.*, 2013).

Various donor-funded research projects reside in the universities, the Water Research Institute and, to a limited extent, in the Fisheries Commission. Some projects are funded under collaborative arrangements among these institutions, a few of which have been referred to elsewhere in this report. There is no national catalogue consolidating information on aquaculture R&D projects and their status to enable an accurate accounting of what has been done and where the gaps are.

Aquaculture education in Ghana is provided, to different extents, by all the major public universities: Kwame Nkrumah University of Science and Technology (KNUST, Ashanti region), University of Ghana (Greater Accra region), Cape Coast University (Central region), and the University of Development Studies (Northern region). KNUST has traditionally led education and research in

²² Personal communication by N. Siaw from Kumah Farms.

inland fisheries and freshwater aquaculture, offering degrees in aquaculture at the Bachelor of Science, Master of Science/Master of Philosophy and PhD levels as a specialization in natural resources degrees. In 2013, KNUST began to offer a Bachelor of Science in aquaculture, fisheries and water resources. In 2015, the university introduced courses with a similar focus as part of the Master of Philosophy Degree.²³ The development of these new degrees is supported by the United States Agency for International Development (USAID) AquaFish Innovation Lab and is intended to emphasize business/entrepreneurship and extension – two most critical yet weak areas for aquaculture education and development in Ghana. Other tertiary institutions involved in training agricultural extension officers are beginning to get involved in aquaculture education, presumably to emphasize aquaculture extension.

5.3 The way forward

The contribution of aquaculture to domestic fish production has overcome its historic insignificance. Reaching about 27 000 tonnes in 2012, domestic aquaculture production has been growing at an average exponential rate of 45–50 percent per year since 2003, stabilizing and possibly narrowing the hitherto widening deficit in domestic production and consumption. Behind the encouraging aquaculture production numbers is a vibrant and growing cage farming subsector that emerged only about a decade ago, and an anaemic pond farming subsector that has existed in the country since the 1950s but currently contributes at most 10 percent of total production. The pond sector faces severely low productivity and inadequate infrastructure, whereas the cage sector faces a high cost of production and a slowing market. Both sectors face rapidly declining real price of tilapia, possibly due to both increased domestic supply and imports of frozen tilapia and other species of fish in spite of a government ban on tilapia importation that is supposed to have been in force for many years.

At an average break-even production cost of more than US\$2/kg, tilapia produced in cage farming in Ghana is more expensive than in many countries in Africa and globally. Farmed tilapia is also more expensive than many locally harvested marine fish species, imported marine fish species, and imported tilapia sold in neighbouring countries. Thus, a partially effective ban on importation has been propping the industry up for rapid growth over a relatively short period of time. The ban will nevertheless outlive its usefulness, as leading tilapia producers are beginning to explore export options in the Western Africa region where some countries have similar bans on imports and others do not. The main reason for the high price of cage-grown tilapia in Ghana is the cost of feed, which at a 2012 average price of about US\$1.30/kg (for 30–35 percent crude protein) and constituting 65–70 percent of the production cost in cage farming. This makes it almost impossible to cut the cost of production. The problem of the high production cost is being aggravated by an unrelenting depreciation of the Ghana cedi against the United States dollar as most large farmers still depend on imported feeds.

Compared with Egypt, for example, feed cost is double to triple in Ghana for 30 percent crude protein feed (El-Sayed, 2013). This is one reason the Government of Ghana should pay increasing attention to the improvement of pond farming by facilitating access to the right type of feed and best aquaculture practices. Pond farming, done properly, can cut the FCR obtained in cages in half. In addition, tilapia grown in ponds through grow-out and fattening can do well on extruded feed with 25 percent crude protein, the cheaper and most common type of feed used in Egypt (El-Sayed, 2013). At the time of this study, there is no 25 percent crude protein feed on the market in the country. The analysis in this report shows pond farming of tilapia is cheaper with a break-even price about half of cage farming. Another advantageous aspect of pond farming in Ghana is that it is not geographically concentrated like cage farming, and most of the southern part of the country is suitable for pond farming. Pond farms, although mostly small scale, are fairly uniformly distributed throughout the southern regions, ensuring that what is produced is mostly consumed domestically, including by the poor, which serves the improved nutrition and food security objective of aquaculture development. Adopting low-cost technologies for pond aquaculture will ensure that the price of tilapia targeted at the local market is

²³ S. Amisah, KNUST, personal communication.

affordable to average and poor consumers, thereby putting food security through tilapia farming within reach.

On-farm experiments have revealed that given the right feed and water quality, a good tilapia strain and an adequate control of reproduction in ponds, growth is still unsatisfactory because of the shallowness of ponds. Fynn (2014) showed a quadruple increase in farm productivity as pond water depth doubled from below 0.5 m. Approximately 80 percent of fish ponds in Ghana have been constructed manually, and in many parts of the country levees are narrow and poorly compacted; ponds are only knee deep on average. The widespread use of shallow ponds in the country indicates a serious lack of knowledge of pond construction and the role of pond depth in productivity. Other causes of low productivity in ponds include the use of mostly farm-made sinking feeds or just food residues, the continuing widespread use of wild, unknown and mixed strains of tilapia because of inadequate dissemination of improved strains of tilapia to pond farmers and the hatcheries that serve them, and the limited and imperfect use of hormonal sex reversal technology. There are many hatcheries with good success rates of sex reversal, but they serve mostly cage farms and sell fingerlings that are too small. Furthermore, pond farmers' access to these hatcheries is generally limited because the biggest and most successful hatcheries are concentrated around Lake Volta and far from where most of the pond farmers are.

There is a need for Ghana to revamp its extension services and increase efforts towards the education of pond and small- and medium-scale cage farmers on proper husbandry techniques. For existing pond farms, technical and financial assistance will be needed for mechanically rehabilitating ponds. Pond construction and maintenance should be a central part of education of extension officers. Provision of support for mechanical excavation of ponds for new farms will be cost-effective in the long run. Extension officers need to be better trained and better resourced. The number of extension officers per farmer should be vastly increased to make any impact on the development of pond aquaculture in the country.

Most of the causes of low productivity discussed in the previous section can be traced to inadequate extension or technical support. The problem of potential under-reporting of pond aquaculture production is also attributed to the absence of personnel in the field who would know where farms are and where new farms are springing up. Financial assistance that does not directly provide cash to farmers, but creates an environment for increased productivity and efficient movement of products to the market, is likely to make a significant difference in moving pond farming out of its current state of low productivity and low profitability.

The aquaculture industry is currently sustained on a ban on imports. However, the effectiveness of the ban is doubtful. Furthermore, continuing growth in tilapia production and a finite local demand for tilapia will require export from Ghana to other countries where tilapia production is less efficient. Currently, there does not appear to be many prospects for export destinations because other Western African countries (e.g. Côte d'Ivoire and Togo) are importing cheaper frozen tilapia from Asia, and others (e.g. Nigeria) are using import bans to protect their own local industry. Keeping tilapia prices high with a ban to boost local production would have a negative impact on the interest of consumers. The import restrictions may eventually be removed. In order to help the tilapia farming industry in Ghana adapt import competition, the government should begin to slowly phase out the ban, perhaps with quotas that increase slowly annually, and pursue policies that will further reduce the cost of feeds and make Ghana tilapia less expensive and competitive for export.

The Government of Ghana has long had a policy of subsidizing premixed fuel and outboard motors for fishers. The current trajectory of both inland and marine capture fisheries indicates overfishing. Thus, subsidized fishing may not be sustainable. Clearly, more fishing has not been able to bridge the gap between domestic demand and supply while small-scale fish farmers struggle with the high cost of inputs and unaffordable price of the final product. Taking subsidies out of fishing is good for sustainability of the natural fisheries, but it will achieve even more dramatic results if such funds are directed towards solving problems besetting aquaculture development in Ghana. Fishers who go out

of business because of the loss of subsidies should be encouraged to go into fish farming. The withdrawal of fishery subsidies can be accomplished in phases over a period of several years to minimize the potential of a drastic shortage of fish.

In summary, the authors suggest the following policy recommendations.

- Increasing attention should be paid to pond aquaculture development for low cost production and competitively priced tilapia for local consumption.
- Incentives should be provided to facilitate local production of low-protein feed for pond farming and educate pond farmers on the benefit of using good feeds and feeding strategies. A low-protein feed market can only be sustained if a sufficiently large number of pond-based farms adopt the feed. Widespread adoption has to be preceded by product availability, demonstration of effectiveness and education of farmers. Feed importers and local producers will naturally move in that direction once a steady local demand is established.
- Use of good quality seed such as the Akosombo strain of *Oreochromis niloticus* should be further promoted. As this strain is more broadly disseminated, the quality of brood will have to be maintained by continuing improvement in specialized hatcheries that have the requisite expertise. More hatcheries, such as the Pilot Aquaculture Centre and the Department of Fisheries in Ashaiman, should be established in the Brong Ahafo, Western and Central regions with trained staff to carry out long-term dissemination and maintenance of brood quality.
- Public hatcheries could be established in proper geographic locations to improve farmers' access to and reduce the cost of good quality fingerlings. The hatcheries should be staffed and equipped to provide training (i.e. effective extension services) in addition to producing and selling fingerlings to farmers. Incentives should be provided to the private sector for establishment of inputs, such as feed distribution businesses around the government hatcheries.
- Private hatchery and nursery development could be promoted through training of prospective farmers.
- Sex reversal of *O. niloticus*, especially in government hatcheries, should be done with pond farmers in mind. The government should facilitate training of its staff, including short-term training in foreign countries or periods of attachment to private hatcheries in Ghana that are more successful with the technology. Manual sorting of the sexes of tilapia is feasible on very small-scale production, yet should not be the standard practice adopted for increasing the productivity of pond systems.
- Nursery development should be encouraged (e.g. through the provision of start-up loans), and should be strategically located for easy transport of fingerlings from the large hatcheries. It is not clear that new grow-out pond farms are needed in Ghana, especially if new farms follow the path of existing ones, but interest in fish farming remains high. Much effort should be dedicated towards improvement in productivity at this time. Prospective entrants into pond farming should be encouraged to consider going into nurseries and provided with appropriate training. Available resources should be channelled into improving the productivity of existing farms first. When a new and better productivity level is attained, efforts could be refocused on the expansion of production. At the current stage, the government should encourage those better educated in the technical and business aspects of fish farming to enter the industry, especially when direct support (e.g. loans) from the government is involved.
- Extension is inadequate in terms of training aquaculture and extension-specific techniques, number of staff per district or farmer, and equipment to accomplish the work. The government could learn from Kenya's economic stimulus programme that turned around aquaculture extension in the country (Republic of Kenya, 2010).
- A ban on imports of tilapia, or fish in general, is not sustainable in the long term and hence should be removed. The existing ban may be ineffective given the evidence that it has never been fully enforced and the tilapia farming industry in Ghana is already expressing the desire to export to other countries because of decreasing domestic demand.

- The government should engage more actively in setting development priorities in aquaculture and not leave it all to donors and development partners so that efforts in helping aquaculture development in Ghana could be more consistent and coordinated.
- Consistent and accurate record-keeping on fish farms and annual reporting of production should be a required condition for permit granting or renewal.

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III. SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN KENYA

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ACKNOWLEDGEMENTS

The authors wish to express sincere appreciation for the support received from the Principal Secretary, State Department of Fisheries and Blue Economy, Ministry of Agriculture, Livestock and Fisheries, for his valuable guidance. The authors' gratitude goes to the technical officers of the State Department of Fisheries and Blue Economy who provided valuable data, and recognize the support and invaluable contribution of the County Directors of Fisheries, County Governments. The authors appreciate the universities, the private sector and the other stakeholders in the sector who took time to provide valuable inputs. AquaFish Collaborative Research Support Programme (AquaFish Innovation Lab) is acknowledged for partially funding the collection of the data used in this report. The authors would like to thank all the fish farmers who took part in some of the field trials and allowed extension personnel to interview them and collect additional information. The authors would like to acknowledge colleagues, including D. Liti, J. Munguti, K. Obiero and K. Charo for discussing various aspects of tilapia culture in Kenya. Finally, the authors acknowledge and appreciate the tireless efforts and commitments demonstrated by the technical team that developed this report.

1. AQUACULTURE DEVELOPMENT IN KENYA: AN OVERVIEW

Aquaculture makes an important contribution to livelihoods, economic development and food security in Africa (Quagraine, Amisah and Ngugi, 2009). The effective start of aquaculture in most of sub-Saharan Africa was, in the 1950s, under the impetus of the various colonial administrations. The Abuja Declaration on sustainable fisheries and aquaculture called for increased fish production, focusing more on aquaculture promotion and development (Kaliba *et al.*, 2007). It is increasingly recognized that promoting aquaculture as a business could yield adequate and solid benefits from the sector, and thereby leading to its sustainable development.

Similar to many countries in Africa, aquaculture production in Kenya has been low and stagnated over the past decade (Hetch, 2006). The slow progress of aquaculture growth in sub-Saharan Africa has been attributed to institutional, biotechnical and economic factors (Hecht, 2006).

Rural fish farming in Kenya dates back to the 1940s and was popularized in the 1960s by the Kenya Government through the “Eat More Fish Campaign”. The number of small-scale farmers increased and peaked at about 20 000 in 1985, with annual production of slightly over 1 000 tonnes (Aloo and Ngugi, 2005).

The period between the early 1970s and early 1990s is regarded as the golden age of donor support to aquaculture development in Kenya (Quagraine, Amisah and Ngugi, 2009), a period when the Government of Kenya partnered with various development partners, both government and non-government agencies, to develop aquaculture. Unfortunately, donor support for aquaculture declined significantly in the mid-1990s for various social and economic reasons, one of which was the shift in priorities to national and international social issues such as HIV/AIDS and global terrorism (Hetch, 2006). From 1980 to 1996, aquaculture contributed about 0.7 percent of the total annual fish supply in Kenya with nearly 98 percent of all fish supplies coming from freshwater (Neira, Engle and Ngugi, 2009).

Kenya Vision 2030, which is a development programme in Kenya launched by the government covering the period from 2008 to 2030, has identified agriculture (crops, fisheries and livestock) as one of the key sectors to deliver the 10 percent annual economic growth rate envisaged under the economic pillar. To achieve the targeted growth, transforming smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector is important (GoK-ASCU, 2013). In recognition of its potential contribution to the economy, aquaculture has been designated as one of the flagship projects of Vision 2030. The overall objective is to increase fish production by 10 percent annually from the current 150 000 tonnes to 450 000 tonnes by the year 2030.

In fiscal years 2009/10 through 2012/13, the government spearheaded the realization of the Vision 2030 flagship project through the Fish Farming Enterprise Productivity Programme under the overall Economic Stimulus Programme. Under the programme, several activities were undertaken, including expanding areas under fish farming to cover arid and semi-arid lands and coastal areas that had not been developed. Intensive awareness creation among small-scale farmers about the viability of fish farming as an alternative agricultural enterprise has led to a major leap in aquaculture activities in the entire country.

A major expected result of the Vision 2030 aquaculture flagship project is an increase in per capita consumption of fish from 3.75 kg to 10 kg by 2030, as well as the objective of narrowing the gap between the country’s per capita fish consumption and the world average.

The growth of the sector was given a further boost by development initiatives, including the FAO Technical Cooperation Project in western Kenya, the FAO/United Nations Development Programme initiative in the coastal and Lake Victoria basin regions, the German Agency for International Cooperation (GIZ) project in western Kenya under a Kenya-Germany-Israel trilateral arrangement,

and the United States Agency for International Development (USAID) funded Pond Dynamics/Aquaculture Collaborative Research Support Programme, among others. Such initiatives have played a significant role in promoting new fish farming technologies among small-scale farmers (GoK-MFD, 2011; Ngugi *et al.*, 2011).

1.1 Resource endowments and utilization for aquaculture development

Kenya is located in equatorial east Africa and shares borders with Uganda to the west, the United Republic of Tanzania to the south, South Sudan to the northwest, Somalia to the northeast, and Ethiopia to the north. The country's area is approximately 582 600 km². Kenya has 536 km of coastline along the Indian Ocean and various inland water resources (e.g. lakes, dams and rivers) suitable for farming a wide variety of fish species of commercial and food value. The inland water surface is about 13 400 km², including major lakes such as Turkana (6 405 km²), Lake Victoria-Kenyan side (4 128 km²), Naivasha (210 km²), Baringo (129 km²) and Jipe (39 km²).

According to the 2009 Kenya Population and Housing Census, Kenya's population totalled 38 610 097, of which 59 percent lived in rural areas. The average population density was 56 inhabitants/km², but the distribution was highly influenced by the climate and the agroecological zone.

Kenya's population and agricultural activity are heavily concentrated in the southern half of the country. The northern half, by contrast, is sparsely populated and characterized by fragmentary infrastructure coverage. Rapid population growth has exerted immense pressure on the quality and quantity of natural resources including water.

Kenya is deemed a chronically water-scarce country, according to international standards on per capita availability of freshwater resources (Mogaka *et al.*, 2006). The challenge of water scarcity has become increasingly severe in the country with its estimated total renewable freshwater resources per capita declining in the past two decades, from 1 226 m³ per person per year in 1992 to 711 m³ per person per year in 2012.¹ Kenya is also highly vulnerable to rainfall variability and climate changes. Extreme weather events, including droughts and floods, have become more frequent.

According to a national aquaculture suitability map developed in 2009 by the Ministry of Fisheries Development (GoK-MFD, 2009) in an effort to map suitable areas for aquaculture investment/development in 210 constituencies in Kenya, most of Kenya's area (96 percent) is suitable for aquaculture to some extent. Specifically, nearly 10 million ha had high suitability; nearly 41 million ha had medium suitability; and a little over 3 million ha had low suitability.

Most of the suitable land for aquaculture development in Kenya is currently under different land use. Its release for aquaculture would depend on several factors, including the development of farmed fish marketing systems, the profitability of aquaculture as compared with alternative land use, the prevailing costs of water harnessing and land resources, the availability of aquaculture inputs and supplies, and the strength of technical and extension services.

In spite of its 536 km of coastline with 12 nautical miles (NM) of territorial waters and 200 NM of the exclusive economic zone, Kenya has little coastal or marine aquaculture. FAO statistics only show a small amount of shrimp aquaculture production in Kenya during the 1980s and 1990s.

Fish farming in Kenya has focused on inland aquaculture of freshwater fish, which accounts for nearly its entire aquaculture production since the 2000s. Land occupied by inland freshwater aquaculture is a negligible area generally found in crop-growing areas where aquaculture competes with other farming activities for resources.

¹ The estimations were obtained from FAO AquaStat on 22 July 2014.

In a bid to alleviate poverty through increased food production and minimization of environment degradation, a major priority development need of the government has been low-cost aquaculture, which promises to increase availability of quality protein food to communities in the short term (FAO, 2004). Because of this policy drive, earthen ponds and dam aquaculture have been the dominant and preferred culture systems due to their cost-effectiveness. As indicated by a national aquaculture inventory conducted in 2005 (Ngugi and Manyala, 2009), most of the total 720 ha of aquaculture area in Kenya contained dams (nearly 500 ha) and earth ponds (220 ha). Other farming systems (cages, tanks, raceways, etc.) occupied a relatively small area, but their yields could be higher than pond or dam culture because of higher density.

1.2 Status and trends of aquaculture development in Kenya

Most of the fish production in Kenya comes from inland capture fisheries (primarily in Lake Victoria). Although Kenya has over 500 km of coastline, marine capture fisheries contributes only a small portion of the country's fish production.

Aquaculture used to account for the smallest share in Kenya's fish production, yet rapid aquaculture expansion in recent years has made it overtake marine capture fisheries as the second major source of fish production in the country. Even so, according to FAO statistics,² (inland) aquaculture still contributed to only 13 percent of Kenya's 187 000 tonnes of total fish production in 2013; capture fisheries from inland waters (83 percent) and marine waters (5 percent) contributed the rest.

The distribution of aquaculture activities by region indicates a high concentration of aquaculture activities in a number of counties and a low density in others. Specifically, high density activities were found in Kakamega, Kisumu, Siaya, Kisii, Kiambu, Kirinyaga and Meru counties, while relatively low activity was noted in Kitui, Nakuru, Baringo and Trans Nzoia.

Prior to 2007, several initiatives were introduced by the government, but there was slow adoption of fish farming by entrepreneurs because of the lack of information on fish farming technology and culture practices, limited funding from the government, and low political support (Nyandat and Owiti, 2013). In 2002, there were only 4 742 fish farmers with 7 471 ponds occupying 217 hectares and producing 962 tonnes of farmed fish. The contribution of farmed fish at that time was just about 1 percent of the fish production. After being stagnant at a level of around 1 000 tonnes at the beginning of the 2000s, aquaculture production in Kenya increased significantly to over 4 000 tonnes in 2007 and to over 12 000 tonnes in 2010 and reached nearly 24 000 tonnes in 2013.

The rapid increase in Kenya's aquaculture production since 2007 could be explained in part by government policies and funding of projects that have promoted fish farming for food, income and employment. Recent political disturbances have not diminished support for fish farming, but instead created more awareness and the need for the government to generate more income alternatives for small-scale farmers. The government therefore, for the first time, has upgraded the State Department of Fisheries to a full ministry and has increased funding for aquaculture.

The funding for the sector was provided through the Fish Farming Enterprise Productivity Programme (FFEPP) under the Economic Stimulus Programme (ESP) that began in financial year 2009/2010 and continued to 2011/2012. Activities within the FFEPP covered key aspects of aquaculture, including pond construction and management, seed management (broodstock, hatchery and stocking density), and feed management (e.g. feed trials, performance evaluation of different feeding practices).

One major achievement of the FFEPP/ESP was the construction of more than 48 000 fish ponds (average of 300 m² each) in 160 constituencies throughout the country (Nyandat and Owiti, 2013). Concurrently, fish farmers built their own ponds and doubled the total number of ponds constructed

² Unless specified otherwise, FAO data on fish production quoted in this paper are obtained from FAO Fishery and Aquaculture Statistics. Global production by production source 1950–2013 (FishStatJ).

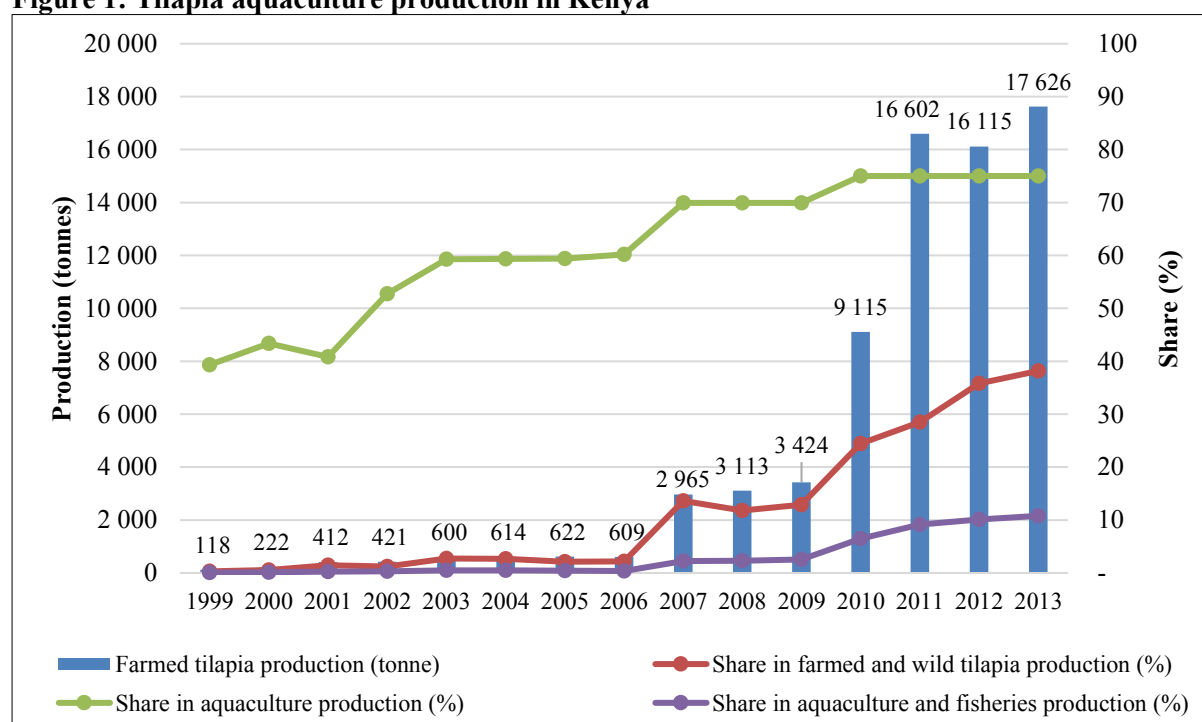
countrywide. As a result, Kenya's total fish farming area in ponds doubled from about 500 ha in 2010 to over 1 000 ha in 2011. The government programme also produced a critical mass of well-trained pond constructors and engineers.

Major aquaculture species in Kenya included Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*) and rainbow trout (*Oncorhynchus mykiss*); their shares in the country's aquaculture production in 2013 were 75 percent, 18 percent, 6 percent and 1 percent, respectively. Farming of endemic species such as air-breathing lungfish (*Protopterus aethiopicus*) and Ningu (*Labeo victorinus*) was tried, but has not yet become substantial.

2. TILAPIA FARMING AND VALUE CHAIN IN KENYA

Tilapia has been the dominating aquaculture species in Kenya. Tilapia aquaculture production increased from a little over 100 tonnes in the late 1990s to nearly 18 000 tonnes in the early 2010s. Its share in the country's total aquaculture production increased from about 40 percent to 75 percent; its share in total (farmed and wild) tilapia production increased from less than half percent to nearly 40 percent; and its share in total fish production increased from nearly nothing to over 10 percent (Figure 1).

Figure 1: Tilapia aquaculture production in Kenya



Source: FAO Fishery and Aquaculture Statistics.

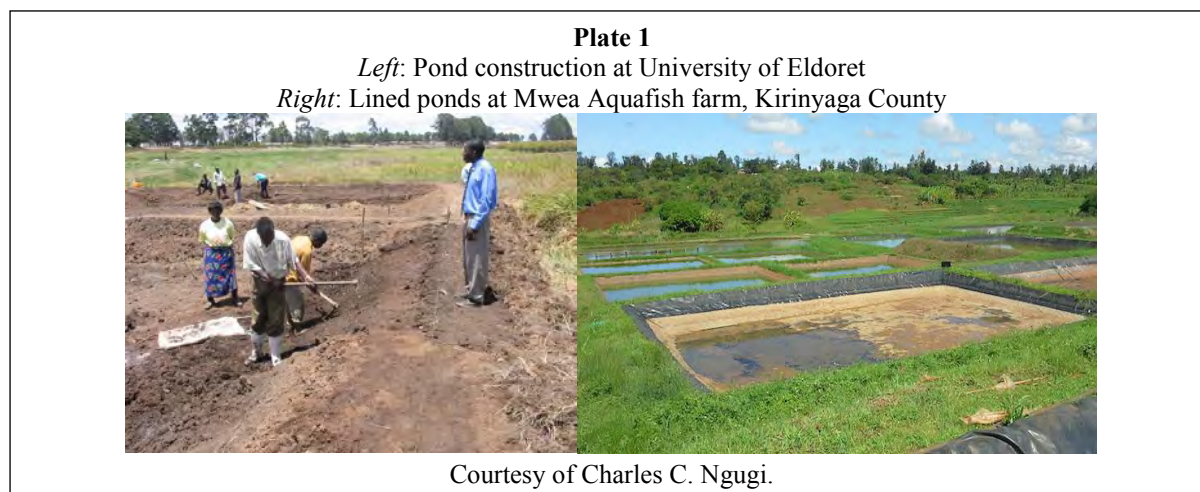
The 2005 National Aquaculture Inventory showed that tilapia was farmed in 97 percent of the total 4 313 identified aquaculture production units (Ngugi and Manyala, 2009). Nile tilapia appears to be the only tilapia species substantially farmed in Kenya.

2.1 Farming system and technology

The earthen pond is the most popular system used by tilapia farmers in Kenya. The economic viability of pond tilapia culture is further enhanced by the warm year-round climate, suitable land, and availability of relatively large quantities of water in most areas. A major drawback of pond tilapia

culture is the high risk of uncontrolled reproduction when effective measures are not in place to control the problem.

Most small-scale fish ponds in Kenya are earthen ponds constructed manually. The common pond size is 300 m² with the depth varying from 45 cm to 110 cm. In places where temperature is suitable for tilapia farming yet land resources are limited, farmers may construct ponds in soils with poor water retention capacity and use pond liners to prevent leaking (Plate 1).



Many pond tilapia farmers in the country use chemical and/or organic fertilizers to enhance natural productivity and supplement with locally available feed ingredients such as cereal bran. The average yield of such semi-intensive systems is between 1 000 and 2 500 kg/ha per year (Ngugi and Manyala, 2009).

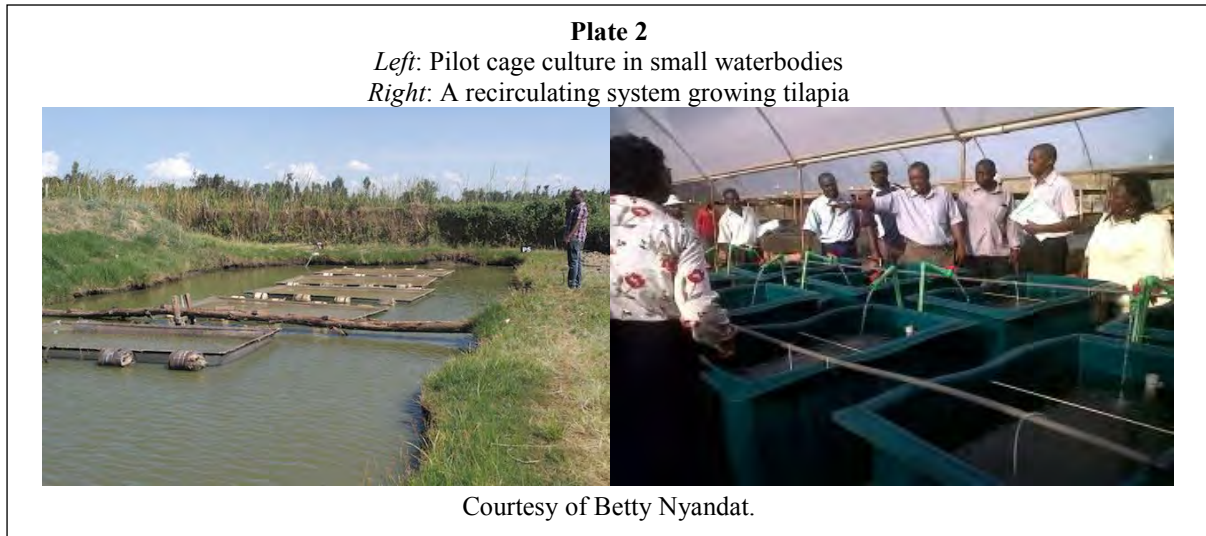
Some tilapia farmers in Kenya use extensive farming systems in earthen ponds or dams that depend entirely on natural productivity with little inputs of fertilizers or feeds and hence have lower stocking density and yield than semi-intensive pond culture (Ngugi and Manyala, 2009). Some tilapia farmers suspend small cages (average 1 m³) in large waterbodies (lakes, rivers, dams or water reservoirs) and let the fish feed on organic matters flowing through. Such an extensive system is usually adopted for subsistence purposes and have relatively low yield.

Trials on commercial cage culture in lakes or ponds in Kenya (Plate 2) commenced in 2005. However, even with great interest created in recent years, cage aquaculture has not been widely undertaken because of constraining factors, including the lack of technical know-how and guidelines, the lack of quality feed suitable for cage farming, potential conflicts with other lake users, and environmental concerns.

Trials on cage culture in Lake Victoria have been undertaken in Kenya, the United Republic of Tanzania and Uganda since 2012 and supported by the Association for Strengthening Agricultural Research in Eastern and Central Africa. Fish species used in the trials included Nile tilapia (*Oreochromis niloticus*) and indigenous Victoria tilapia (*Oreochromis esculentus*). The size of the cages used averaged 8 m³. Stocking density from 10 to 100 fish/m³ was implemented in various growth trials. An assessment (including a detailed spatial analysis) was conducted in 2013 to examine the suitability of Lake Victoria for cage culture. In light of the growing interest in introducing cage culture in Lake Victoria, there is an urgent need to put in place regulations and guidelines governing cage culture.

Tanks or raceways are not a widely used aquaculture system in the country, as they tend to be technically and financially demanding in terms of both construction and operation. Only a few fish farmers in Kenya use intensive tank or raceway systems, such as the recirculating system used by a

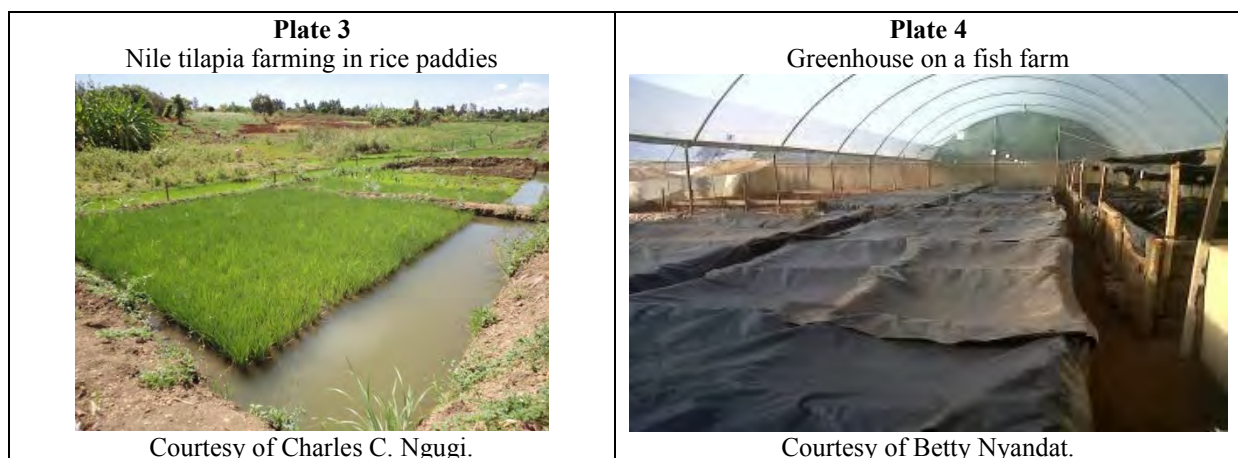
tilapia farm in Kirinyaga County (Plate 2). While not yet popular in Kenya, intensive systems have potential to have more significant contribution to aquaculture production in terms of both volume and value in the long run.



Most tilapia farmers in Kenya grow monoculture tilapia as the targeted species. There are a few farmers polyculturing tilapia with African catfish (*Clarias gariepinus*) to control prolific breeding of tilapia and to increase production. Tilapia and catfish polyculture also helps prevent the growth of harmful bacteria and serves to remove excess organic matter in the water (Troell, 2009). There are trials with other fish species, including common carp (*Cyprinus carpio*), black bass (*Micropterus salmoides*), barbus (*Barbus altianalis*), goldfish (*Carassius auratus*), labeo (*Labeo victorinus*), crayfish (*Procambarus clarkii*), mosquito fish (*Gambusia affinis*), and rainbow trout (*Oncorhynchus mykiss*).

Integrated rice-fish farming (Plate 3) appeared in Kenya as a new technology of tilapia farming by small-scale fish farmers. The system is gaining prominence in many rice growing areas, including Mwea, Bumala, Ahero, Rae, Kabonyo and West Kano.

To enhance temperature and reduce the growth period, some farmers grow Nile tilapia in various types of greenhouses (Plate 4) to raise the temperature for increased growth, breeding and shortening growth period.



2.2 Seed

A shortage of good quality seed has been a bottleneck for development of tilapia farming in Kenya. Traditionally, many tilapia farmers (especially small-scale farmers) restock self-grown fingerlings or purchase them from neighbours. Such fingerlings tend to be low-quality seed. Although farmers could purchase tilapia seed from commercial seed producers, they are often unsatisfied with the quality of fingerlings supplied from private hatcheries (size, growth, mortality, etc.), especially since they have to rely on trust on whatever they are given, as at the very early stage it is difficult to know whether the fingerlings are of good quality or not.

The construction of about 48 000 fish ponds in 160 constituencies throughout the country under the FFEPP/ESP triggered a big demand for fingerlings. Suppose that each pond stocked 1 000 fingerlings,³ 48 million fingerlings would be needed to fully stock these ponds. However, even with the help of the FFEPP/ESP, only 39 million fingerlings were actually stocked (Wagude, 2013).

The government subsidizes the production and distribution of tilapia fingerlings to mitigate the seed shortage and encourage the development of freshwater fish production among rural residents. As the private sector is expected to become the primary mover of the seed industry, the government has used regulatory functions to facilitate participation of the private sector in the seed business.

In order to improve tilapia seed quality, the government has established a system of accreditation in which no hatchery would be allowed to operate without government ascertaining the quality of broodstock or without necessary facilities and training capacity. At the beginning of the FFEPP/ESP, the government released guidelines to all certified seed producers and revised them annually. The government also put in place procedures for accreditation of fish hatcheries. In June 2011, there were 129 accredited fish hatcheries, both publicly and privately owned. The accreditation process is an ongoing activity and those hatcheries not adhering to the guidelines are delisted. The aim is to ensure that each county gets sufficient numbers of accredited hatcheries for sustainability of aquaculture activities.

The government also provided capacity building to help improve seed quality. For example, a training programme for hatchery managers was initiated at the National Aquaculture Research Development and Training Centre in Sagana. All hatchery managers were encouraged to join the programme. One of the objectives of the training programme was to help seed producers or farmers to understand management strategies for maintaining the quality of brooders.

While many hatcheries still stock brooders in ponds at a ratio of one male to two females, more sophisticated seed producing systems, such as hapas and raceways or tanks (Plate 5), have appeared and become increasingly popular. Seed standards have been developed to guide both farmers and hatcheries on seed quality in such systems.

Seed availability and quality have increased as a result of adoption of improved seed production practices by the private sector. However, the practice of stocking fingerlings or fry self-produced or purchased from neighbours is still widespread among farmers, even as the government tries to ensure that there is an accredited seed producer within their constituencies and that fish farmers purchase fingerlings only from authenticated fish hatcheries. Various government aid programmes (funding pond construction cost, provision of free fingerlings and/or feed, extension services, etc.) are expected to help address the problem of purchasing poor quality seed by making quality seed available at an affordable price to small-scale farmers.

³ The average pond size is 300 m² and the stocking density is 3–3.5 fish/m².

Plate 5

Left: Tilapia seed production in hapas
Right: Tilapia hatcheries under construction



Courtesy of Betty Nyandat.

2.3 Feed

Similar to the general situation for aquaculture in sub-Saharan Africa (El-Sayed, 2013), tilapia farming in Kenya relies primarily on farm-made feeds, as commercial (pelleted) feeds are too expensive for most tilapia farmers, especially for small-scale farmers.

Most of the farm-made tilapia feeds in Kenya use oilseed cakes (cotton, soybean or sunflower), freshwater shrimp and/or fishmeal as protein sources; the energy sources include rice and wheat bran, corn, kitchen wastes and/or vegetables. Such feed ingredients are mixed at predetermined ratios by hand or with the aid of mechanical mixers. The resulting feed dough is processed by a simple device (e.g. a meat mincer or pasta maker), or a pelletizing machine that makes moist strands that are dried and broken up into suitable pellet sizes (Plate 6).⁴

Plate 6

Left: Feed pelletizing machine given by the government to cluster farmers
Right: Sun drying of pelleted feed



Courtesy of Betty Nyandat.

From 2010 to 2013, the government, through the FFEPP, provided 54 fish farmer clusters with feed mixers and pelletizing machines for the purposes of producing fish feeds not only for their own use but also for sale to other farmers. The government also provided feed producers with research support for feed formulation and development and published aquafeed standards through the Kenya Marine and Fisheries Research Institute and the Kenya Bureau of Standards. Standards on the requirements

⁴ This is similar to the farm-made feed producing technique described in detail in El-Sayed (2013).

for compounded tilapia feeds used as a complete diet for tilapia have been developed. According to Vision 2030, the demand for certified feed is expected to increase to 200 000 tonnes in the medium and long term.

2.4 Processing

Tilapia in Kenya is usually traded fresh with little processing. Farmed tilapia sold at farmgate is usually sold whole without processing (Wagude, 2013), yet there is inadequate knowledge and information about processing methods at the farm level. The lack of product diversification reflects local consumers' preference over fresh fish. Low tilapia fillet yield (about 30 percent), which makes tilapia fillet expensive, is another contributing factor.

Tilapia is processed into diverse product forms, such as fillet, portioned or cured, for high-end niche markets. Tilapia not sold timely or low-quality tilapia (second grade and below) are sometimes processed (e.g. smoked or dried) for preservation.

A combination of smoke, salt and drying, which is one of the traditional methods of food preservation, continues to be used among fish traders in Kenya. Smoking or smoke preservation has the benefit of removing spoilage bacteria and poisonous elements (Hilderbrand, 1992; Abidemi-Iromini *et al.*, 2011). Smoking remains a favourite processing method in the sector due to its low cost and value addition through improvement in the flavour, appearance and/or texture of the product. Simple drying is undertaken in two ways: the fish is either split open and sundried or it is deep fried in oil. The methodology applied for sun drying split open fish is cheap and simple and remains a favourite in the tilapia sector due to its cost-effectiveness and the availability of abundant tropical sunlight. This particular product targets low-end domestic markets and has relatively low value addition. Deep-fried tilapia, which is mainly prepared for restaurants and hotels, is more expensive yet remains a favourite of Kenyan consumers because of its favourable taste and convenience.

To encourage further processing, the Kenya Government supports the establishment of cold storage and mini-processing plants in various places in the country. Farmers are trained and encouraged to add value by processing their fish into different products. One rationale behind the government's effort stems from the expected high yields from the established 48 000 fish ponds during the ESP. Data from the fisheries statistical bulletin in the past ten years also indicate a growing demand for fish in the country, which creates great opportunities for the growth of aquaculture business.

2.5 Trade

Fish trade in Kenya flows through domestic channels and the export channel. The domestic channels supply fish to wholesale markets, retail markets and food service operators (food kiosks, hotels and institutions such as schools and hospitals), while the export channel mainly targets markets outside of the country.

The entrance of farmed fish into mainstream fish trade has been slow and inefficient. This is partly because of the fragmentation and dispersion of fish supply locations as well as the inconsistent and low-volume harvests that result in high operational costs of marketing and distribution. The marketing channel for aquaculture products in Kenya is therefore short and usually direct from producers to consumers or retailers (farmgate sales) with no organized marketing.

As farmed fish production has been steadily increasing over the years, it is expected that aquaculture products will join the formal distribution channels of wild-caught fish and governed by the dynamics of normal fish market trade. The features of wild-caught fish trade include: (i) intermediary interference and price fixing; (ii) variation in prices depending on the retail shop and clientele; (iii) payments of consignment after sales; and (iv) seasonal variations in fish supply from wild capture fisheries that often cause oversupply in the market during the April/May high season.

The wholesale market segment comprises fish producers (farmers or fishers) and wholesalers who play a key role in assembling fish produce from scattered farmers and linking them to markets. Independent wholesalers trade fish according to market conditions, whereas contract wholesalers buy fish and sell to specific retailers or institutions or to food kiosks based on their contractual obligations. Generally speaking, fish wholesalers determine fish prices, whereas most producers are price takers. Fish wholesalers also control the entry of fish products into the markets and sometimes become a bottleneck obstructing efficient fish distribution (Wagude, 2013).

The retail market segment is composed of supermarkets, municipal fish markets and open-air fish markets. Key supermarkets that sell fish products in Kenya include Uchumi, Nakumatt and Tuskys. These outlets carry imported farmed tilapia, which is gaining prominence because of its low shelf cost and regular supply. Supermarket retailers handle as high as 100 kg of imported farmed tilapia fillets per day. Distributors that sell to supermarkets usually charge a relatively low markup compared with other distributors because they deliver a large volume of orders per stop. A distributor that delivers fish products to supermarkets typically charge 5 to 10 percent markup for frozen products, yet 15 to 20 percent for fresh items because of more handling and greater loss. Supermarkets with full-service fish departments typically mark up the price of fish between 35 and 45 percent.

Municipal fish markets are located in municipally designated and designed fish markets in the main urban centres and composed of individual or company traders who exclusively sell fish products in well-developed fish shops or in specific market areas dedicated for retailers. In this retail segment, fish can be sold in various forms such as frozen or fresh whole, frozen or fresh fillets, marinated whole, or marinated fillets. Traders handle both wild caught and farmed fish. Each trader usually handles between 30 and 200 pieces of fish per day. Traders have basic yet inadequate ice facilities, inadequate fish display cabinets, poor handling and sanitation, and inadequate water supply in the markets. There are also butcheries that handle fish and fish products. The live fish niche market is being explored by butcheries that are mainly targeting catfish in holding facilities with a water pump to recycle or aerate water. Most butcheries have better facilities for displaying and holding fish; most of them have freezing facilities. Entry into municipal fish markets is usually difficult as they are controlled by cartels who determine the buying price.

Open-air fish markets represent the main sales outlet for farmed tilapia in rural areas. Traders in this retail segment purchase fish daily from fish farmers, fishers and/or wholesalers and sell the produce by the roadside on simple wooden racks or sacks spread on the ground. Each trader usually handles between 20 and 200 pieces of fish per day and sells all the fish purchased within the same day. They usually lack a fixed building or location, ice facilities, running water, and good handling and sanitation practices. However, if well organized, this segment could become a major driving force of tilapia aquaculture because of its proximity to both farmers and consumers.

The export channel for the aquaculture sector received a boost when Kenya was admitted into the list of countries approved to export aquaculture products to the European Union (EU) through the Commission Implementing Decision (EU) 2015/1338 (30 July 2015). The EU market has been the traditional export market for Kenya fish. It is expected that farmed tilapia exports would ride on the already developed trade infrastructure before diversifying into other markets. The EU market has been a favourite destination for exports not only because of the competitive prices the market offers, but also because of the zero tariffs enjoyed by Kenya through the Economic Partnership Agreements between the EU and the East African Community in 2015. Kenya is also a member of the Common Market for Eastern and Southern Africa (COMESA) and the East African Community Customs Union free trade area, which implies great market potential for Kenya's fish products in the member countries of the trade blocs, including Burundi, Comoros, the Democratic Republic of the Congo, Djibouti, Egypt, Eritrea, Ethiopia, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, the Sudan, Swaziland, Uganda, the United Republic of Tanzania and Zambia. Table 1 lists the tariffs on Kenya's fish products in some international markets.

Table 1: Tariffs on Kenya's fish export to international markets

Importing country	Total ad valorem equivalent tariff (%)	Year
East African Community	0	2013
European Union/United Kingdom of Great Britain and Northern Ireland	0	2013
South Africa	3.54	2013
United States of America	0.04	2013
Australia	0	2013
Canada	0.45	2013
China	10.22	2011
Democratic Republic of the Congo	13.13	2014
Egypt	0	2009
China, Hong Kong SAR	0	2013
Israel	42.4	2008
Japan	4.25	2011
Republic of Korea	14.21	2009
Malaysia	0.26	2008
Thailand	59.49	1999
Singapore	0	2013
Sri Lanka	14.52	2012
Switzerland	0.09	2013

Source: GoK-Ministry of Livestock and Fisheries Development unpublished data.

Like any commodity, fish exports in the international trade arena are regulated by national and international trade policy or agreements. The World Trade Organization (WTO) is a key international forum for discussion of tariff issues. The WTO desk, which is stationed at the Kenya Bureau of Standards, is in charge of informing the sector about any proposed tariff changes in the world. Unfortunately, the sector does not participate in trade negotiations effectively, and there is a need to strengthen the effectiveness of fisheries participation in the Doha round of negotiations. This is especially important given that most value-added processed fishery products categorized under HS16 attract higher tariff rates. For a country like Kenya, where policy frameworks increasingly encourage value addition, such “tariff escalation” (i.e. higher tariffs on processed and semi-processed products than unprocessed goods) could become a major constraint.

In the process of exploring international markets, the tilapia farming sector in Kenya must be prepared to contend with non-tariff trade barriers, including: (i) customs and administrative entry procedures (e.g. country of origin, import licensing and custom evaluation rules); (ii) technical barriers to trade (e.g. traceability and certifications such as ecolabelling); (iii) sanitary and phytosanitary measures (e.g. the Hazard Analysis Critical Control Point – HACCP – method); and (iv) safeguard and anti-dumping measures.

2.6 Consumption and prices

Kenyans consume over 70 percent of the country's fish production. Virtually all farmed fish are consumed domestically. Main fish species that serve direct human consumption or industrial uses (e.g. feed production) include Omena (*Rastrineobola argentea*), Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*). Tilapia continues to dominate as the fish of choice for local consumers.

According to the Statistical Bulletin 2010 of the Ministry of Agriculture, Livestock and Fisheries, total fish consumption in Kenya was 108 000 tonnes in 2009. This implies an average of 2.7 kg/capita per year, which is much lower than the 17 kg/capita per year of the world average. According to FAO

estimates, in 2011 fish accounted for 7.5 percent of total animal protein intake in Kenya, which is much lower than the African average (19 percent) and the world average (17 percent).⁵

The results of studies carried out in central and eastern Kenya under the BOMOSA fish project (Liti *et al.*, 2009; Munguti *et al.*, 2009a, 2009b, 2009c) indicated that: (i) fish was considered to be a superior protein source; (ii) fish was not consumed regularly by households; (iii) some people did not consume fish because of taste (unpleasant smell and bones), health (allergic to fish) or other reasons (e.g. strict vegetarian); (iv) men usually consumed fish more often and for a longer period than women; (v) tilapia was the most consumed fish in both central and eastern regions, yet many consumers preferred catfish than tilapia; (vi) fish at or above 250 grams were preferred for more flesh and bigger bones; (vii) fish was mainly prepared by deep frying or stewing; and (viii) men were more knowledgeable and skilful in fish preparation than women.

In order to address the issue of low per capita fish consumption, the government reintroduced the Eat More Fish campaign with a changed name of “Kuza, Kula na Kuuza” (Farm, Eat and Sell) campaign. The countrywide campaign teaches communities how to farm fish, the economic benefits of fish farming, how to prepare and eat fish, and the health benefits of eating fish. The initiative was undertaken by the Ministry of Agriculture, Livestock and Fisheries in collaboration with the Nutrition Department.

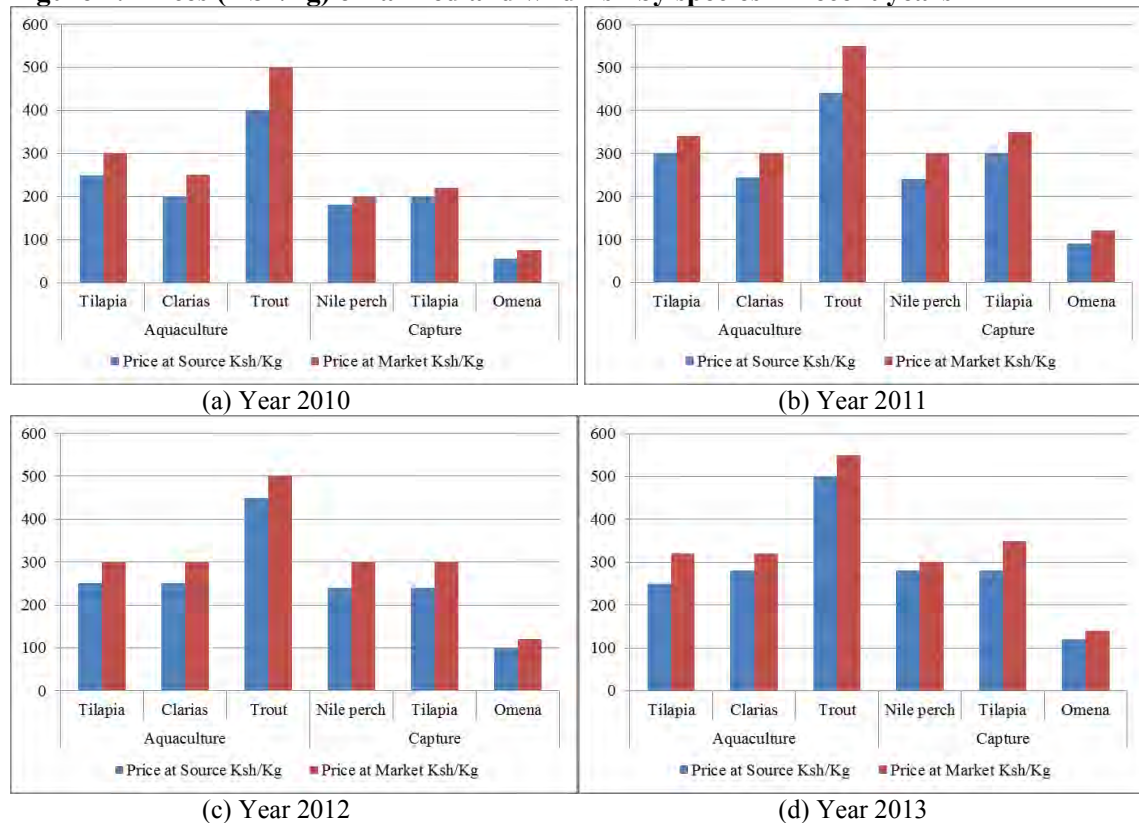
In Kenya, a survey aimed at developing best marketing strategies for smallholders in aquaculture was conducted in March 2012 under a FAO Technical Cooperation Project, with sample target groups being drawn from Luanda (Vihiga County), Yala (Siaya County) and Lurambi (Kakamega County). The evaluation involved organizing a tasting day where fish farmers cooked farmed tilapia for members of the public to solicit their opinions on the taste of the fish. The purpose of the survey was to try to change the general negative public perception of farmed fish (e.g. not flavoured and/or muddy taste). The objective of this activity was to determine consumer acceptability so as to ensure there is wider market access to farmed fish and fish products. In the case of the target group in Yala, 43 people tasted the fish, with 26 of them interviewed on camera and confessing that farmed fish was tasty. Out of these, 19 people said that farmed fish was sweeter than lake fish.

It is, therefore, evident that people will generally eat fish irrespective of the source because the taste of fish, whether from the lake or farmed, is almost the same with negligible difference. The rejection of farmed fish is due to myths, misconceptions and misinformation, which can be changed through events such as tasting days and media promotions. Currently, there is special emphasis on improving farmers’ perception of the profitability of fish farming. In practice, it is necessary to show farmers that fish farming, when properly managed, is profitable in economic terms.

Price is determined by supply and demand. Fish supply is mainly influenced by the domestic external supply factors such as local weather, closed seasons for other fish species and culture cycle periods, while demand is influenced by locality (urban/rural centre), competition from other protein sources and pricing, among others. Because of changing supply and demand conditions, the prices of fish commodities are volatile and can fluctuate considerably. While the fish price at farmgate tends to be flexible, the situation changes the moment the supply enters the formal value chain. Fish prices in large markets such as Gikomba and city markets are usually controlled by a cartel of agents who determine the prices.

The price of farmed tilapia tends to be affected by those of competing commodities, including aquatic products such as wild tilapia, Nile perch, *Clarias* and Omena, as well as other animal protein sources such as beef and chicken. Figure 2 shows the prices of farmed tilapia and other aquatic products in recent years.

⁵ The share of fish in total animal protein intake is calculated based on data provided by the FAO food balance sheet (accessed 22 July 2014).

Figure 2: Prices (KSh/kg) of farmed and wild fish by species in recent years

3. ECONOMIC PERFORMANCE OF TILAPIA FARMING IN KENYA

The economic performance of tilapia pond culture is assessed in this section based on typical technical and financial parameters in Kenya. The results are presented in United States dollars for ease of comparison at the exchange rate of US\$1 = 84 KSh (Kenya shilling).

3.1 Cost

Major costs of tilapia farming in Kenya include capital cost (land, pond, machinery, etc.), material cost (seed, fertilizer, feed, fuel, etc.), and labour and professional services (wages, consultancy fees, etc.).

Capital investments

Building a 300 m² tilapia pond could cost US\$350 in Kenya, which implies US\$1.17/m² or US\$11 700/ha. Given a depreciation period of 20 crops (eight months per crop), the amortized pond construction cost would be US\$583/ha per crop.

A 1 hectare tilapia farm would need equipment and tools worth about US\$1 786. Given a depreciation period of 10 crops, the amortized cost of equipment and tools would come out to be US\$179/ha per crop. A landless farmer may need to acquire land by purchasing or renting it, which could cost US\$8 648/ha (US\$3 500/acre) or US\$741/ha per year (US\$300/acre per year), respectively.

Seed

Mixed-sex tilapia fingerlings cost US\$0.036 (KSh 3) per fingerling, whereas monosex seeds cost US\$0.06 (KSh 5) per fingerling. Tilapia farmers in Kenya usually stock two to three mixed-sex fingerlings per m² or three to four monosex fingerlings per m². Farmers usually stock catfish

fingerlings (5 to 10 percent of the number of mixed-sex tilapia fingerlings) in tilapia ponds to control unintended propagation.

Feed

Tilapia farmers in Kenya usually use pellet feed for monosex fingerlings and powder feed for mixed-sex fingerlings. Feed prices are about US\$0.95 (KSh 80) per kilogram of pellet feed (30–32 percent crude protein) and US\$0.60 (KSh 50) per kilogram of powder feed (28–30 percent crude protein). Tilapia feed with lower protein content would be cheaper. For example, pellet feed with 15 percent of crude protein is about US\$0.48 (KSh 40) per kilogram. Feed conversion ratios (FCRs) are about 2 for pellet feed and 2.5 for powder feed or low-protein pellet feed.

Other materials

Urea and diammonium phosphate (DAP) are used to fertilize tilapia ponds at 528 kg/ha per crop and 256 kg/ha per crop, respectively. The prices of urea and DAP are US\$0.60 (KSh 50) per kilogram and US\$0.71 (KSh 60) per kilogram, respectively. The use of lime is 2 500 kg/ha per crop; its cost is US\$0.12 (KSh 10) per kilogram. The costs of fuel and electricity are US\$1.3/litre and US\$0.17/kilowatt, respectively.

Labour and professional services

The costs of a farm manager, worker and security guard are US\$250, US\$105 and US\$87 per person per month, respectively. Technical consultation could cost US\$100 per day. Harvest could cost US\$105 per day. Transportation could cost US\$500 per year.

Financial charges

The annual interest rates for short-term and long-term loans are 19 percent and 15 percent, respectively.

3.2 Profitability

Suppose a tilapia farm in Kenya stocks 35 000 fingerlings in a 1 ha pond area, recruits one manager, two workers and one security guard, harvests 10 tonnes of fish after eight months with the FCR being 2, and sells the produce at the price of US\$3.57/kg. Table 2 examines the enterprise budget of the operation.

The results indicate that the farm would earn a profit of US\$8 458 in an eight-month cycle, which implies a monthly earning of US\$1 057 (nearly KSh 90 000). This is at the level of a middle-class income in Kenya.

A major factor behind the profitability is the good tilapia farmgate price (US\$3.57/kg) in Kenya, which is higher than the prices at international markets. Indeed, the farm would stay profitable only when the farmgate price is higher than US\$2.72/kg. This break-even price appears to be higher than tilapia farmgate prices in major tilapia producing countries such as China.

The US\$0.85 difference between the cost (US\$2.72/kg) and the price (US\$3.57/kg) represents a 24 percent profit margin that gives the farmer resilience against unfavourable prices or production fluctuations. However, the profitability assessment in Table 3 does not consider financial expenses that could be incurred when the farm needs to borrow money to finance its establishment and/or operation. For example, suppose the farmer needs to borrow US\$22 134 at 15 percent annual interest rate to finance the land purchase (US\$8 648), pond construction (US\$11 700), and the purchase of equipment and tools (US\$1 786), then the interest payment for a production cycle (eight months) would reduce the profit by US\$2 213, increase the break-even price to US\$2.94/kg, and reduce the profit margin by 6 percent.

Table 2: Profitability of a 1 hectare tilapia farm in Kenya

Item	Unit	Quantity	Price (US\$/unit)	Value (US\$/ha/cycle)	Notes
Seed	No. of fingerlings	35 000	0.06	2 100	Stocking 3.5 fingerlings per m ²
Feed	kg	20 000	0.95	19 000	FCR being 2
Fertilizer and lime				799	
Urea	kg	528	0.60	317	
Diammonium phosphate (DAP)	kg	256	0.71	182	
Lime	kg	2 500	0.12	300	
Labour and professional services				4 581	
Manager	Person-month	8	250	2 000	One manager
Worker	Person-month	16	105	1 680	Two workers
Security	Person-month	8	87	696	One security guard
Harvest				105	
Technical consultation				100	
Depreciation				762	
Pond				583	
Equipment and tools				179	
Total cost				27 242	
Production and revenue	kg	10 000	3.57	35 700	8-month production cycle
Profit				8 458	

4. SOCIAL PERFORMANCE OF TILAPIA FARMING IN KENYA

4.1 Food and nutrition security

While it is a common view that aquaculture could have a significant contribution to food security and poverty alleviation, the direct and indirect impacts of aquaculture on food security and poverty alleviation in Kenya have not been adequately measured, let alone the specific contribution of tilapia farming. This shortfall hinders efficient and effective planning, implementing and coordinating investments in the sector to increase the impact of its development on the poor and hungry, as well as sectoral initiatives, or increasingly larger multisectoral food security investments. It is important to strengthen the information and knowledge base surrounding aquaculture in general and tilapia farming in particular in terms of their contribution to food and nutrition security and poverty alleviation.

4.2 Income and employment

The fishery sector (including both aquaculture and capture fisheries) in Kenya contributes about 0.50 percent to the country's GDP (GoK-KNBS, 2012) and provides livelihoods to many riparian and coastal residents. The sector supports about 1.1 million people directly and indirectly, including fishers and/or fish farmers, traders, processors, materials and service suppliers, and employees and their family members. In monetary value, the sector earned the country over KSh 5 billion (US\$60 million) in 2011 in foreign exchange through exports of fish and fishery products (GoK, 2013).

The Government of Kenya has injected KSh 5.7 billion (US\$68 million) over a five-year period that began in 2009 to implement the FFEPP/ESP, which is expected to provide full-time jobs to over

150 000 fish farmers and short-term employment to over 1.5 million youths and create more than 500 000 indirect employment opportunities at various stages of the value chain (GoK, 2012). Different types of interventions are needed to support and improve the livelihood of smallholder aquaculture households. In Kenya, small-scale aquaculture (SSA) is no longer a subsistence production activity to meet household food consumption, but has become a major supply of fish products to national markets. It has also become a major livelihood source for smallholder aquaculture households through commercial operations. The promotion of SSA development has become an important approach for rural poverty alleviation in the country. The interventions needed to support and improve the livelihoods of SSA households include bridging the gap between the SSA households with the market (inputs and products), provision of improved technical services, empowering the SSA households in market negotiations and compliance with good governance and meeting the standards of food safety and quality, and reducing the economic vulnerability of SSA households.

4.3 Women and youth

Gender has become a central issue to a number of developmental programmes in Kenya. Every sector in the country is required to develop a gender policy to ensure a gender-balanced approach in its activities. Gender issues have received adequate policy and institutional support starting from the Constitution (2010). The State Department of Fisheries has put strategies in place to ensure gender mainstreaming in fisheries.

The participation or involvement of women in aquaculture activities is probably low due to the fact that, traditionally, men own the land. More often than not, in rural areas women manage fish ponds and men take charge of harvesting and receiving the proceeds.

One of the important social developments in Kenya in the last two decades is the establishment of women, self-help and youth groups. Such groups have facilitated empowerment of women and youth. In many cases, groups established for rural development have taken up aquaculture as an income-generating activity. One of the current development activities is the formation of fish farming clusters. Women are members of such clusters, and they should be duly represented in leadership positions.

5. GOVERNANCE AND INSTITUTIONS

5.1 Legal and policy framework

The Government of Kenya has initiated the development of a comprehensive National Aquaculture Policy to provide clarity towards efficient management, development, research and regulation to enhance the full potential of the aquaculture sector. The policy is to facilitate the National Aquaculture Strategy and Development Plan 2010–2015. The policy, strategy and plan have been aligned to the Fisheries Act Cap 378 (revised 2012), the National Oceans and Fisheries Policy 2008 (to be revised), and the Ministry of Fisheries Development: Strategic Plan 2008–2012 (under revision). Table 3 provides a list of key legal and policy instruments underpinning the governance of aquaculture and fisheries in the country.

The Environmental Management and Coordination Act (EMCA) 1999, together with the Environmental (Impact Assessment and Audit) Regulations 2003, provides the legal framework for the environmental assessment. The Environmental (Impact Assessment and Audit) Regulations 2003 stipulates the procedures for undertaking environmental assessments in Kenya. The EMCA (1999) specifies the environmental impact assessment for projects likely to have adverse impacts on the environment. The EMCA (1999) also stipulates the strategic environmental assessment regarding policy documents (such as the National Aquaculture Strategy and Development Plan 2010–2015 and the National Aquaculture Policy 2011) as a starting point in addressing environmental and sustainable development challenges of the sector.

Table 3: Policies and legislation related to aquaculture

Policies and legislation		Remarks
Legislation		
1	Fisheries Act Cap 378, 1991 (revised 2012)	Due for review
2	The Fisheries Management Bill 2012	Approved for publishing and to be tabled in parliament
3	Fisheries (Beach Management Unit, BMU) Regulations, 2007, L.N. 402/2007	BMU Regulations, 2007
4	Aquaculture Environment Assessment Pollution Monitoring Regulations	Regulations required
5	Fish Levy Trust Fund Regulations	Draft regulations
Policies		
6	National Oceans and Fisheries Policy 2008	Due for review
7	National Aquaculture Policy	Operational, but requires review
8	National Oceans Policy	A draft has been prepared
9	National Fish Quality Assurance and Marketing Policy	Policy required
Documents supporting policy		
10	Fish Marketing Strategy Guidelines	A draft has been prepared
11	Guidelines for Environmental Management of Sustainable Aquaculture Development in Kenya	Draft ready, but needs final editing; regulations required
12	Prawn Fishery Management Plan 2010	Due for review
13	Lobster Management Plan	Draft to be finalized and subject to stakeholder validation
14	Manual of Standard Operating Procedures (MSOP)	Draft being edited

5.2 Government

The State Department of Fisheries, which was established via Executive Order No. 1 of 18 April 2013 under the Ministry of Agriculture, Livestock and Fisheries, is the main agency governing aquaculture and fisheries in Kenya. It is mandated to facilitate the exploration, exploitation, utilization, management, development and conservation of fisheries resources as well as aquaculture development, and to undertake research in marine and freshwater fisheries. The department undertakes policy formulation, administration including licensing and settling of legal conflicts, planning development programmes, promulgation of rules and regulations, training, and research. It comprises four directorates, including: (i) aquaculture development; (ii) inland and riverine fisheries; (iii) coastal and marine fisheries; and (iv) fish safety, quality assurance and marketing.

Guided by Vision 2030 and the country's second medium-term plan, the State Department's draft Strategic Plan (2013–2017) established five strategic objectives: (i) developing or reviewing policy and the legal framework for fisheries management and development, and harmonizing it with the Constitution of Kenya; (ii) increasing aquaculture and fisheries production by 10 percent annually up to 2017; (iii) reducing post-harvest losses of fish and fishery products from approximately 25 percent to 5 percent by 2017; (iv) increasing per capita fish consumption from the current 3.75 kg to at least 6 kg per person by 2017; and (v) enhancing the capacity of the State Department of Fisheries for improved service delivery.

5.3 Farmer organizations

There are various aquaculture associations in Kenya, distributed in high-potential areas under the umbrella of the Aquaculture Association of Kenya or the Commercial Aquaculture Association of Kenya. These associations provide a forum for communication with government agencies, especially for capacity building (training), contacts with extension officers, development partners and linkages to markets.

Most of the fish farmer associations in regions that grow tilapia are not as active as expected. These associations need to focus on buying quality feed in bulk for members, negotiating or providing credits to members, and helping members market their produce.

The Government of Kenya, USAID and FAO have developed pilot market-driven clusters in line with the new approaches for aquaculture development, as defined in the Kenya National Aquaculture Strategy and Development Plan 2011, and in concert with methodologies outlined in the FAO Special Programme for Aquaculture Development in Africa as endorsed by the African Union. These clusters develop economies of scale and market share for smallholders, allowing them to optimize benefits from their fish farms (aqua-businesses). The approach was based on regrouping fish farmers with a minimum economic farm size into marketing clusters with an overall minimum economic size (e.g. a cluster being able to produce at least 35 tonnes per year with a corresponding minimum water surface area of 6.4 ha). These farmers function as an economic unit, scheduling reliable supplies of high quality, consistent products to customers who pay a premium for fresh tilapia.

6. OPPORTUNITIES, CHALLENGES AND THE WAY FORWARD

Kenya has favourable climate for tilapia farming. The tropical, and in some instances near equatorial climate, is ideal for tilapia farming without the need for “wintering” during cold seasons. The country has ample underutilized water resources and potential sites for aquaculture. Increasing public attention and political will to aquaculture development has created a conducive environment for the sector to grow. The elevation of aquaculture into a directorate under the fully fledged State Department of Fisheries presents an excellent opportunity for aquaculture issues to be handled more efficiently and effectively.

However, a variety of challenges and constraints would need to be addressed and overcome for Kenya to fully exploit its potential in aquaculture in general and tilapia farming in particular. Some such issues and constraints are similar to those identified in the country’s Agricultural Sector Development Strategy 2010–2020 (GoK, 2010), including: (i) inadequate and/or inappropriate legal and regulatory framework; (ii) reduced effectiveness of and inadequate capacity in extension services; (iii) inadequate infrastructure (e.g. road and electricity) and facilities (hatchery, cold storage, etc.); (iv) low adoption of modern technology; (v) inadequate storage and processing facilities; (vi) limited capital and access to affordable credit; (vii) inadequate government funding; (viii) high cost and/or low quality of key inputs (e.g. seed and feed); (ix) pre- and/or post-harvest losses; (x) inadequate markets and marketing infrastructure; (xi) insufficient water storage infrastructure; and (xii) increasing incidence of various diseases (e.g. AIDS, malaria, water-borne and zoonotic diseases) that result in loss of productive labour and human capital.

Aquaculture development in Kenya is also constrained by the lack of human resources in aquaculture. Farmers generally lack knowledge and skills in aquaculture. Progress in this regard has been hindered by the lack of appropriate training and extension services. A related problem is the country’s underdeveloped research capacity in aquaculture because of inadequate funding and human resources, lack of demand-driven research, and the unstructured information dissemination mechanism.

Aquaculture is fully devolved to the county government, while capture fishery is a function of the central government. Fisheries policy development in Kenya can be traced back to 2006 with the publishing of the National Oceans and Fisheries Policy, but the policy direction covered more of capture fisheries than aquaculture. There is a need to develop a stand-alone aquaculture policy, taking into consideration the devolved system, functions and challenges in tilapia value chain development. The Government of Kenya has prepared a draft national aquaculture policy to address the main challenges and has revised a number of legislative articles and regulations to accommodate the needs of aquaculture development in the country.

Many tilapia hatcheries operating in Kenya have been registered to supply fingerlings under both the ESP and FFEPP. However, there has been little certification of these hatcheries because standards and procedures are still under development, and structures and institutions for certification have yet to be put in place at the time of this writing. The government has committed in the draft National Aquaculture Policy to facilitate the mobilization of resources for the development of aquaculture facilities toward the management of genetic resources in aquaculture and aquatic biosecurity.

The need for certification in aquaculture in Kenya is currently being addressed under the new draft policy on regulations. The aim of regulations will be to streamline specific aquaculture enterprises that could include seed, feed, hatchery, grow-out, input standards and certification processes. At present, there are standards for four categories of tilapia feeds, which could form a basis for certification of both manufacturers of fish feeds and aquaculture operators who use certified feeds. There are already feed standards developed in Kenya. The policy direction is to put in place regulations that would facilitate the creation of aquaculture professional organizations to oversee the operation of relevant operators, such as feed manufacturers, hatchery operators and professional service providers.

The current policy direction for grow-out farmers is to organize them into production clusters in order to facilitate their access to inputs, extension services and markets. The government has put in place plans to provide cold storages in a number of high production areas.

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IV SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN NIGERIA

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ACKNOWLEDGEMENTS

The authors appreciate the coordinators of federal government projects – the National Programme for Food Security, our strategic partners. The technical support from the Fisheries Society of Nigeria, the Nigerian Association of Fish Farmers and Aquaculturists, the Nigerian Institute for Oceanography and Marine Research, and the National Institute for Freshwater Fisheries Research is gratefully acknowledged. The authors appreciate the cooperation of some private tilapia fish producers, especially Durante Fish Industries, Ibadan, Nigeria, who gave us unhindered access to their tilapia cage culture farm and hatcheries. Finally, the authors are immensely grateful to FAO for giving us the opportunity to contribute to knowledge on tilapia farming in Nigeria.

1. OVERVIEW OF AQUACULTURE DEVELOPMENT IN NIGERIA

The first attempt at fish farming in Nigeria was in 1951 with various tilapia species being cultured (Longhurst, 1961). Prior to 1960, over 2 000 small-scale subsistence ponds were built, with some growth continuing in rural areas (Adikwu, 1999; Miller and Atanda, 2004; Fagbenro, Akinbulumo and Ojo, 2004). In spite of that modest growth, the contribution of aquaculture to the country's fish supply was small (generally less than 5 percent) until the early 2000s. During the early stages of aquaculture development in Nigeria, the most commonly cultured species were indigenous tilapias whose popularity stems from their hardiness and prolific breeding. In the absence of adequate management, pond culture of tilapia proved disastrous to the chagrin of fish farmers and extension agents and led to the abandonment of tilapia by many rural farmers.

Fish is a favourable animal protein for Nigerians, contributing about 28 percent of the total animal protein intake in 2000.¹ With the country's large population of about 170 million (NPC, 2006), the strong demand for fish has led to a significant growth of commercial aquaculture in peri-urban areas (Fagbenro, 2012; Afolabi, Imoudu and Fagbenro, 2005). Many abandoned fish farms have been rehabilitated and new farms established since 2000, mainly small to medium enterprises as well as a few large-scale intensively managed fish farms. The market-driven growth has increased the country's aquaculture production by an average of 20 percent per year, from about 26 000 tonnes² in 2000 to nearly 280 000 tonnes in 2013. The share of fish in total animal protein intake increased by 40 percent. Nigeria has become the largest aquaculture producer in sub-Saharan Africa. The next phase of expansion is being developed by the government, including youth employment programmes that focus on fish farming training (FDF, 2012). Aquaculture development in Nigeria is being promoted through the entire value chain and led by the private sector, while the government plays a facilitative role of providing a conducive business environment.

In Nigeria, indigenous and introduced fish species have been cultivated in ponds, impoundments, lakes, reservoirs, floodplains, cages and irrigation canals. Tilapias (*Oreochromis* spp., *Sarotherodon* spp. and *Tilapia* spp.) and catfishes (*Clarias* spp., *Heterobranchus* spp., and their reciprocal hybrids) are the most widely cultured species. Introduced species such as the common/mirror carp (*Cyprinus carpio*) (Olaniyan, 1961; Ajayi, 1971; Welcomme, 1988) and Indian major carps – catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) (Nwanna, Fagbenro and Balogun, 1998) – have also shown satisfactory performance, especially in the central and southwest zones.

Catfish farming in Nigeria has become very successful because of the low production cost, excellent market, availability of good quality seed and feed, availability of technical assistance, and access to credit through cooperatives, among other factors. In 2013, catfishes accounted for 65 percent of the country's aquaculture production, whereas the shares of tilapias and carps were 7.8 and 8.4 percent, respectively.

2. TILAPIA PRODUCTION AND VALUE CHAIN

2.1 Tilapia production

Tilapias are suited to low-technology farming systems because of their fast growth rate, hardiness, efficient converters of supplementary feeds, resistance to disease, ease of reproduction, and tolerance to wide ranges of environmental conditions (Fagbenro, 1987). Tilapia culture remained largely a subsistence-level activity until 2000, when it began to expand rapidly following the successful commercial farming of catfishes (Alfred and Fagbenro, 2006; Afolabi, Imoudu and Fagbenro, 2000).

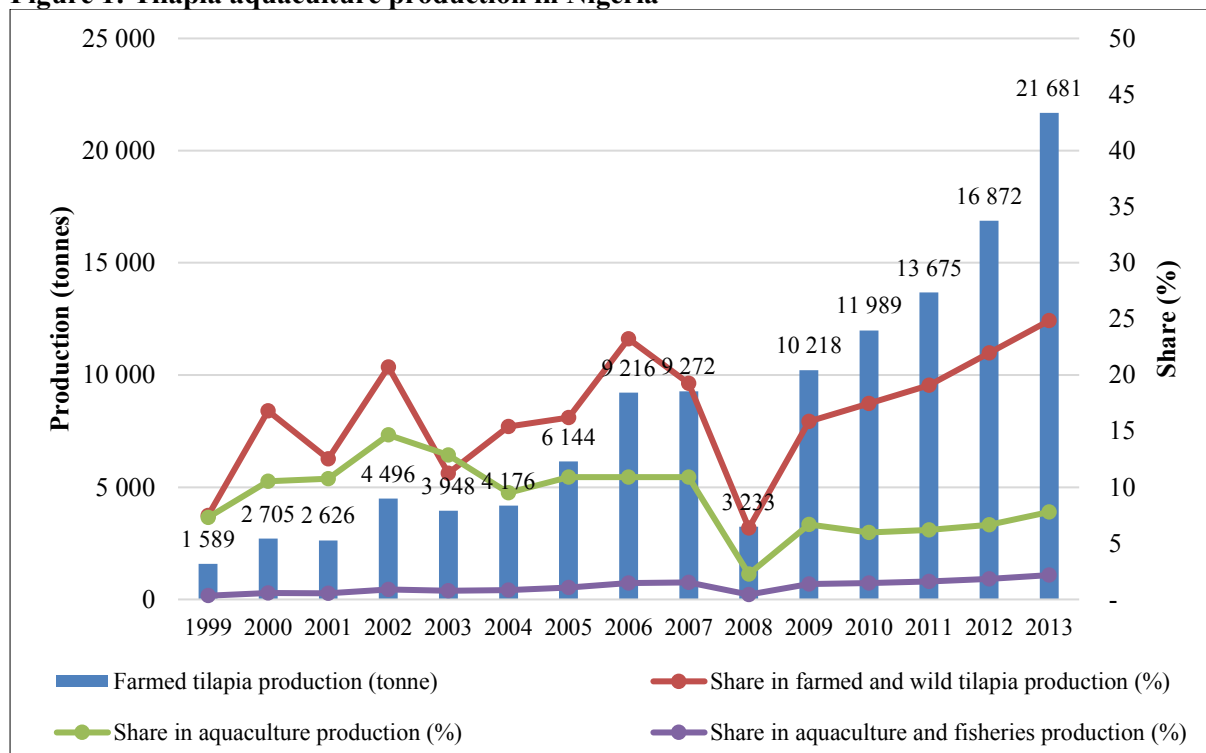
¹ Unless specified otherwise, fish consumption data are from the FAO food balance sheet.

² Unless specified otherwise, aquaculture production data are from FAO fishery and aquaculture statistics on global production by production source 1950–2013 obtained from FishStatJ.

Tilapia aquaculture production in Nigeria increased from about 1 600 tonnes in 1999 to over 21 000 tonnes in 2013, with the share of farmed tilapia in total (farmed and wild) tilapia production rising from less than 10 percent to nearly 25 percent (Figure 1). However, the share of tilapia in the country's total aquaculture production remained at around 7 percent. The share actually increased to nearly 15 percent in the early 2000s, but declined in the late 2000s back to the original level (Figure 1) because of the much faster growth in catfish aquaculture. During the period, the share of tilapia in total fish production increased from less than 0.5 percent to over 2 percent (Figure 1), which reflects faster aquaculture growth relative to capture fisheries in the country.

Nigeria is one of the largest farmed tilapia producers in sub-Saharan Africa. In 2013, production was only less than production in Uganda and Ghana, but tilapia farming has been less outstanding than catfish. Factors that constrained the development of tilapia farming in the country include low input technology (extensive culture system), poor skills of farmers, unintended propagation in ponds, and the consequent stunting and small size of fish harvest as well as low yield and low prices. Until very recently there has not been a deliberate effort either by the private sector or the government to encourage tilapia farming, as against catfish farming, which is enjoying a self-propelling boom because of relatively high profitability and acceptance.

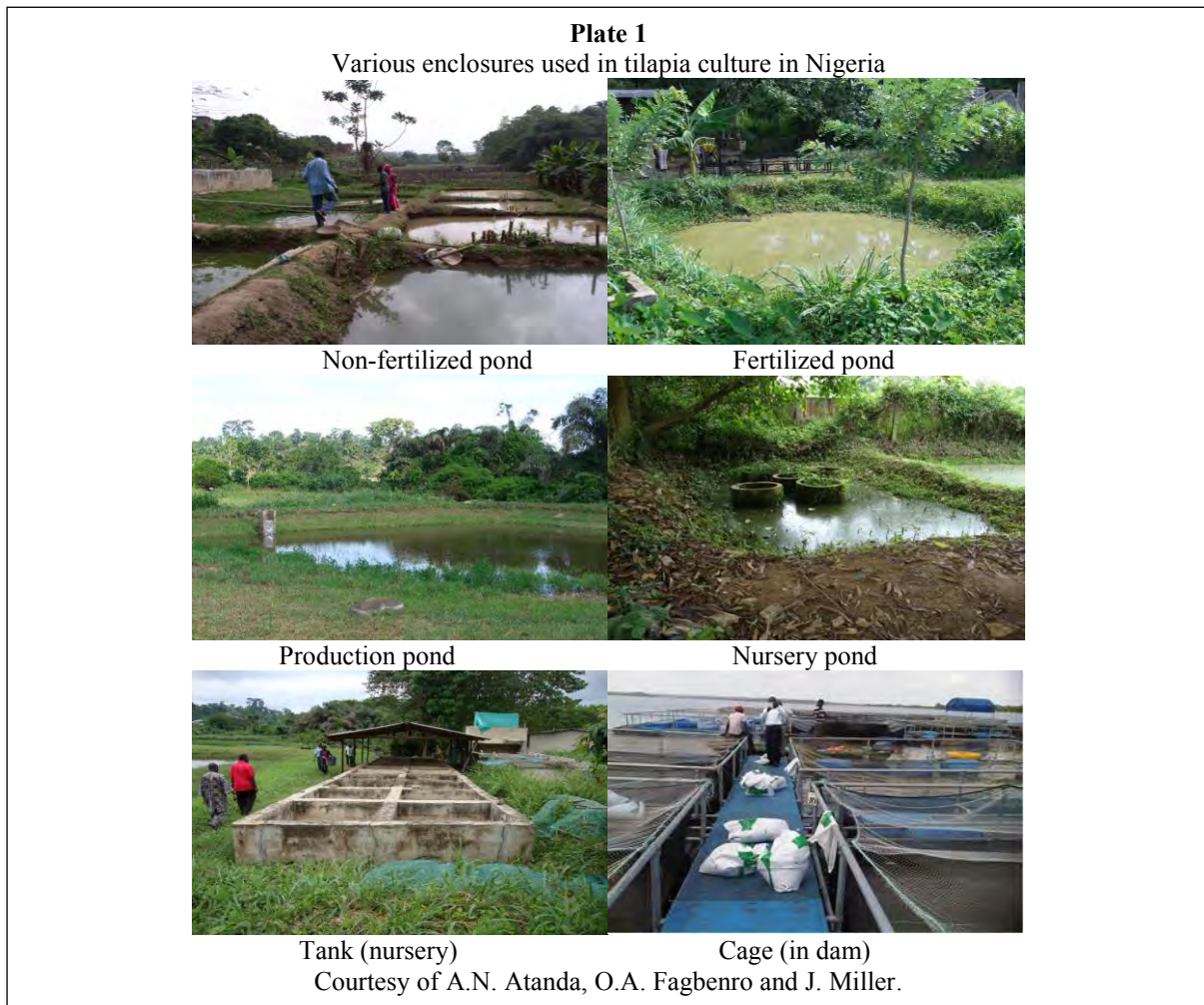
Figure 1: Tilapia aquaculture production in Nigeria



Tilapias are widely cultivated in a variety of culture enclosures (Plate 1), such as earthen ponds, tidal pools, floodplains, reservoirs, concrete tanks, fibreglass tanks, reinforced plastic tanks, hapas, net pens and cages (Dada, 1975; Sagua, 1976; Otubusin, 1985, 1986; Egwui, 1986; Anyanwu, Ezenwa and Uzukwu, 1989; Salami, Fagbenro and Sydenham, 1993; Okoye and Lambe, 2001; Fagbenro, Akinbulumo and Ojo, 2004).

In Nigeria, construction of a one unit concrete tank costs about ₦60 000 each (US\$1 = ₦150.00; Central Bank of Nigeria, January 2014). Yet the cost is reduced by building four tanks together with contiguous walls. Most tanks are built without drains, as it is easy to use a siphon for water draining and to harvest the fish. A fine mesh netting is stretched over the tanks to prevent bird predation. Tanks are built in the open without a shed or hangar. By grouping tanks together, security is facilitated. To account for evaporation and water loss, the water level of about 1 metre is maintained by adding water

into the tanks using pumping machines. The corners of most tanks are rounded so as to reduce oxygen deficits and provide a continuous wall for the fish to follow with reduced injuries.

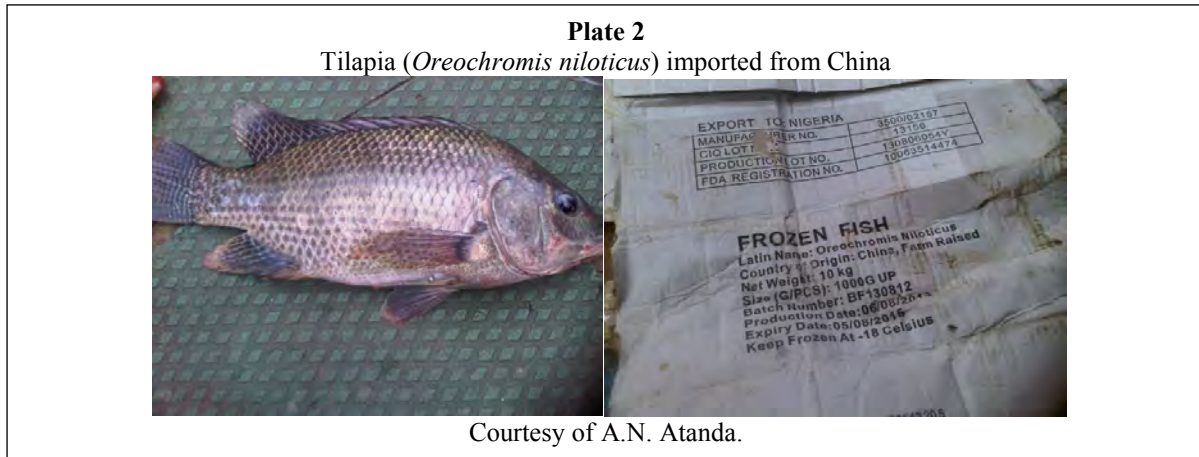


Tilapia is cultivated in various production systems, from monoculture to polyculture with *Clarias* spp., *Heterobranchus* spp., *Cyprinus carpio* or *Heterotis niloticus*. Production levels also vary, from small scale to large scale, for home-consumption, marketing and even processing for commercial purposes. Generally speaking, the productivity of tilapia farming in Nigeria ranges from 200 kg/ha per year in rice-fish farming to over 2 000 kg/ha per year in the more intensive tank culture system (Fagbenro, 2002). The productivity has recently increased to 5 000–6 000 kg/ha per year (FDF, 2012). Under the monoculture system, Dada (1975) reported a tilapia yield of 595 kg/ha per year, while Coche, Haight and Vincke (1994) obtained a tilapia yield of 6 589 kg/ha per year.

A company recently installed 30 cages in Oyan Dam in Ogun State, about 120 km from Ibadan. Each cage is 6 m × 6 m and uses PVC as the frame material. The construction of a module of the floating net cage, including the anchor and floating device, costs US\$10 625/module, with a life span of four to five years. Ten tonnes of red and silver varieties of *Oreochromis niloticus* are harvested from each cage every five months with two cycles a year. The individual average size at harvest is 450–500 grams. Initially, fingerlings (5–8 grams, US\$0.125 per piece) are fed with pelleted feed (Skretting, the Netherlands; crude protein, 30–35 percent), which costs US\$1.75/kg and cheaper than catfish pellets (US\$2.06/kg).

2.2 Tilapia import

It is estimated that as much as 10 000 tonnes of frozen tilapia were imported into Nigeria in 2011 (FDF, 2012),³ more than half of which came from China (Plate 2) and Thailand. Farmed frozen tilapia has also been imported from Ghana and South Africa. Since 2011, there have been campaigns to cut back on the imports of farmed fish, especially catfish and tilapia, to protect the local industry. However, the official import quantity available is far less than the actual quantity in the market as there has been many illegal imports. Data from China customs indicate a large amount of frozen tilapia export from China to Côte d'Ivoire (nearly 15 000 tonnes in 2013). Part of the export may end up in Nigeria through regional trade, which was nevertheless not reflected in the official trade statistics.



Recently, there has been controversy and confusion on fish import restriction policies in Nigeria. In November 2013, the Federal Ministry of Agriculture and Rural Development through the Federal Department of Fisheries announced a ban on the importation of farmed tilapia into Nigeria in order to facilitate domestic fish production. However, the ban was not supported by the Ministry of Trade and Industries, which regulates the importation of goods into Nigeria. While the ban has not been officially rescinded and is under further review, it is not effective at the time of this writing.

2.3 Seed

There are more than 25 species of tilapias in Nigeria, out of which about six species are used for aquaculture, including *Oreochromis* spp. (*O. niloticus* and *O. aureus*), *Sarotherodon* spp. (*S. galilaeus* and *S. melanotheron*), and *Tilapia* spp. (*T. guineensis* and *T. Zillii*). *Oreochromis niloticus* has been the dominant species (Adesulu, 1997; Ayinla, 2007).

In the past, a sizeable amount of tilapia fingerlings were collected from the wild (Ezenwa, Odiete and Anyanwu, 1985). Wild fingerlings tend to be unreliable in terms of both quantity and quality because of seasonality, mixed species, different size, etc. Most of the hatchery fingerlings are produced by small- and medium-scale farms for their own stocking (Ezenwa *et al.*, 2005).

The majority of government fish hatcheries built in the 1970s on which fish farmers depended have been neglected, run down and unproductive. There are about 60 such abandoned hatcheries and fish production centres across the country, and a few of these have been divested to private-sector management (Madu, 2004). The vast majority of fingerling production by private-sector investment has proved to be key to the success of fish farming in Nigeria, along with the use of high-quality fish feeds (Miller, 2010).

³ According to the statistics of the Federal Department of Fisheries in Nigeria, Nigeria imported over 760 000 tonnes of fish in 2011.

Commercial hatcheries have become increasingly popular. The technology for monosex (all male) tilapia farming is now well-known, established and tested in Nigeria. FDF (2012) listed 11 hatcheries with a capacity from 100 000 to 1 000 000 (average 270 000) fingerlings per cycle. Most of them are in the south of Nigeria. Large farms usually have hatcheries to produce fingerlings for their own use and sell the excess to other farmers. A few commercial fish farmers import fingerlings and/or broodstock from other countries, such as Israel, the Netherlands and South Africa. Contract terms are usually not standardized, generally carried out by mutual agreement between supplier and purchaser, and usually on a cash-and-carry basis with about two weeks to one-month advance booking.

Most tilapia farmers stock fingerlings of 15–20 grams, which cost from US\$0.12 to US\$0.16 each, and raise them through a nine-month cycle to 900 grams to 1.2 kg. The expected mortality rate is usually 10 percent due to poor handling or predation. One company uses broodstock imported from the Netherlands to produce tilapia fingerlings for stocking in floating net cages. It takes about four to five weeks to raise fry into 5–8 gram fingerlings (costing US\$0.125 per piece) before stocking.

The stocking density under monoculture in ponds has usually been 10 000 to 20 000 fingerlings per ha for *Oreochromis* spp., 8 000 to 15 000 per ha for *Sarotherodon* spp., and 8 000 to 10 000 per ha for *Tilapia* spp. Catfishes are often stocked in tilapia ponds at the ratio of 10:1 (one catfish for every ten tilapia) to control unintended propagation. When polyculturing with *Cyprinus carpio* or *Heterotis niloticus*, the stocking ratio was 1:1 (Fagbenro, 2002).

The ease with which tilapias spawn and produce offspring make them a good fish to culture. However, prolific breeding, if uncontrolled, tends to result in a large amount of stunted fish (e.g. less than 100 grams), which has low or little market value. The use of predatory species (e.g. African catfish) has been one of the most practical and effective methods used to control unintended propagation in tilapia farming in Nigeria (Fagbenro *et al.*, 2011), whereas the use of monosex fingerlings has become increasingly popular.

2.4 Feed

An inadequate supply of suitable, low-cost, good-quality and standardized feeds has been one of the major constraints deterring the development of tilapia aquaculture in Nigeria. As many fish farmers prefer catfish to tilapia, limited effort has been put in developing standardized tilapia feeds.

The cost of supplementary feeds can account for up to 40 percent of tilapia production cost; the share for complete feeds can reach 60 percent (Fagbenro, 1987; Fapohunda and Fagbenro, 2006). The crude protein content of tilapia feeds used is usually 30–35 percent as compared with 45–50 percent for catfish feeds. Nigeria has substantial production of crops (e.g. maize, sorghum, millet and soybean) that can be used as aquafeed ingredients. Skilled labour trained in the country's agricultural institutions and universities can effectively run a feed mill and market feed pellets.

While using manure to fertilize tilapia ponds has been a common practice in Nigeria, the use of imported floating pellets supplemented occasionally with local feed has gained popularity. Many brands of floating, imported fish feeds are available in shops of animal feed dealers and distributors (Table 1). However, at the subnational level, states usually have a few major aquafeed brands.

Many market structures, including distributors, feed dealers, retailers and professional associations, exist in all the states of the country. Most fish farmers buy feeds from the open market. Some farmers prepare their feeds, while a few have feeds supplied directly to their farms by fish feed dealers. In addition to price and quality, factors that influence the decision-making of fish farmers to buy a particular brand include strategic location of feed depots, adequate distribution network, media advertisement, and efficient supporting services (e.g. extension and training). The type of packaging (strength, size variation, durability, inclusion of nutrient content label) also plays a significant role in the choice of fish feed brand purchased by farmers. Most imported floating feed is packaged in 15 kg bags; a few brands use 20 or 25 kg bags.

Table 1: Examples of commercial fish feed suppliers in Nigeria

Distributors	Brand name (country of origin)	Crude protein content (%)	Price per 15 kg bag in May 2014 (US\$)
Durante Fish Industries	Skretting (the Netherlands)	45	30.94
OT&T Global Ventures Ltd	Multi Feed (Israel)	45	26.87
Felimar Aquaculture Centre	Coppens (the Netherlands)	42	32.82
AEC Integrated Enterprises	Multi Feed (Israel)	45	26.87
Aller Aqua Fish Feed	Aquafeed (United States of America)	45	31.25
Animal Care	Multi Feed (Israel)	45	26.87
Nigerian Institute for Oceanography and Marine Research (NIOMR)	NIOMR Feed (Nigeria)	42	23.75

Source: FDF, 2012.

Note: US\$1 = ₦150.00 (Central Bank of Nigeria, January 2014).

2.5 Processing

Most of the tilapia produced in Nigeria is used for domestic consumption; the supply to export markets is virtually non-existent. Tilapia is mainly sold fresh, smoked, fried, salted, or cooked in various recipes. Value-added products such as fish fingers, fish cakes (Table 2), and other ready-to-serve or convenience fish foods exist and have the potential to stimulate a wider interest in fish consumption. For example, stunted tilapias could be used to produce minced fish cake as a “raw and ready-to-fry” product favoured by the fast food industry (Zain, 1980; Akande, 1990; Eyo, 1996; Aluko, Onilude and Sanni, 2000). Small or stunted tilapias can also be processed into fishmeal or fish silage to use in compounding livestock and fish feeds (Akande, 1990; Eyo 1993). However, such value-adding processes would mostly favour capture fisheries because stunted tilapia from aquaculture is on the decline with increasing use of monosex fingerlings.

Table 2: Formula for spiced minced tilapia cake

Ingredient	g/kg
Minced tilapia	878
Onion (fresh/chopped)	40
Concentrated tomato purée	40
Deodorized vegetable oil	20
Melon (ground)	10
Salt	7
Chili peppers	4
Maggi cubes	0.6
Thyme (dried leaves)	0.2
Curry powder	0.2

Source: Eyo, 1996.

2.6 Consumption and price

Fish accounts for about 40 percent of animal protein consumed in Nigeria. Fish is usually cheaper than other animal protein sources. While tilapia can cost only about US\$2/kg in rural areas, beef and poultry can cost US\$4–US\$5/kg. Generally speaking, there are no social, cultural or religious restrictions on the consumption of fish. However, there could be local taboos on the consumption of a particular species, such as scaleless catfishes that are forbidden by some cultures or faiths.

According to a survey of cultivated food fishes and an inventory of fish farms (Miller and Atanda, 2004), African catfish (*Clarias gariepinus*) was the most popular species favoured by 80 percent of the respondents in terms of consumer preference and economic returns; tilapias were favoured by 14 percent of the respondents. The consumer preference pattern was reflected in a price discrepancy between the two species. For example, the prices of farmed catfishes in May 2014 (around ₦600/kg or US\$4/kg for fresh and ₦1 200/kg or US\$8/kg for cured) were nearly twice as high as those of farmed tilapias (around ₦350/kg or US\$2.3/kg for fresh and ₦600/kg or US\$4/kg for cured).

While Asian communities accept smaller fish sizes, Africans have a strong preference for large table fish (Balarin, 1984). In Nigeria, the marketable size of tilapia is usually at least 150 grams. The small size and bony feature of stunted tilapias from aquaculture generally have low consumer appeal (Moses, 1983).

3. ECONOMIC AND SOCIAL PERFORMANCE OF TILAPIA FARMING

3.1 Profitability of tilapia farming

Tilapia farming in Nigeria has mostly been conducted in semi-intensive or extensive systems relying mostly on supplementary feed. However, given the relatively high feed price yet low tilapia price in the country, it could be challenging to sustain the profitability of a tilapia farming system relying on complete commercial feed.

According to a field survey in southwest Nigeria in 2014,⁴ the price of commercial floating tilapia feed (30 percent of crude protein) was about ₦250/kg (US\$1.67/kg), whereas the price of market-size farmed tilapia (350 grams) was about ₦400/kg (US\$2.67/kg). This implies that the feed conversion ratio would need to be no higher than 1.6 in order for the revenue to cover the feed cost.

Most fish farmers in Nigeria stock fingerlings of 15–20 grams. The price of a 20-gram monosex tilapia fingerling is ₦15 (US\$0.1). Given a 90 percent survival rate and 350 grams of harvest size, the cost of fingerlings would be ₦48 (US\$0.32) per kg of tilapia harvest. A tilapia farm would usually need at least one worker and one security guard. Thus, given the national minimum wage of ₦5 000 per person per month in Nigeria, the labour cost for a farm that produces 5 tonnes of tilapia in six months would be at least ₦12 (US\$0.08) per kg of production. Suppose that the feed conversion ratio is 1.5, which tends to be technically demanding, then the price of farmed tilapia would need to be at least ₦435/kg (US\$2.9/kg) to cover the total cost of feed, seed and labour. This is higher than the normal price of farmed tilapia (₦400/kg). Considering other costs (e.g. energy and depreciation) and the risk of fish farming, the break-even price would tend to be higher.

Tilapia farmed in a good environment may fetch a higher price because of the larger size and freshness, etc. For example, 450–500 grams of tilapias farmed in cages installed in Oyan Dam in Ogun State were sold for US\$4.38 at farmgate. Under this situation, even though the cage farm used expensive feed (e.g. feed used at the fingerling stage cost US\$1.75/kg), the feed cost, which was about 60 percent of the production cost (US\$3.25/kg), was worthwhile.

3.2 Livelihoods

Tilapia has contributed significantly to the livelihood needs and sustenance of many Nigerians in terms of employment and wealth creation. Jobs are created along the tilapia value chain, including construction of ponds, tanks or cages, production of feed, production of seed (wild collection or hatchery production), nursing and outgrowing, processing and value addition, marketing and sales, and so on. In the near future, commercial tilapia production in cages may reach 10 000 tonnes, which will translate to an additional 2 000 new jobs along the value chain as more investors embrace the practice and technology.

3.3 Gender

In Nigeria, more women are involved in tilapia processing, value addition and marketing than men. There are more women involved in the fish trade in most parts of Nigeria, except for northern Nigeria, which has a predominant Muslim population. In the south, more than 70 percent of fish processors are women; tilapia processing is also a popular business for northern housewives who are mostly restricted to work indoors. In parts of Nigeria, where by tradition married women are usually housewives who at best only engage in small domestic trade, tilapia processing that entails sun drying, frying or making a paste as a condiment is a major source of income to supplement the family income. Fresh, smoked or grilled tilapia, as well as tilapia added to stews and pepper soup, is served at local eateries, which are mainly run by women.

⁴ The survey was conducted by Oyedapo A. Fagbenro.

3.4 Human nutrition

Cereal grains, as well as root and tuber crops, provide the main dietary items for many people in Nigeria. However, these foods are not adequate sources of micro and macronutrients (Brown, 1991). Efforts in the past made to improve the nutritional value of staples, especially cereals, were based on fortification of staples with legumes to boost the deficient amino acids (Salami, 1988). According to Okeiyi and Futrell (1983), the resulting improved diets are of variable organoleptic properties and poor digestibility, which is attributed to the low solubility of plant protein. Fasasi, Adeyemi and Fagbenro (2005, 2006, 2007) replaced legumes (plant protein) in the cereal-legume diet with underutilized tilapias (animal protein) with the aim of reducing post-harvest losses. The resultant production of highly digestible novel food from such technology could enhance optimal utilization of the popular species farmed globally.

Considering the potential of “cereal-fish flour” mixes, investigations were conducted on their physicochemical properties as well as storage stability in order to establish the characteristics that may affect their role in food systems during processing and storage and hence their usefulness and acceptability for industrial and consumption purposes. While tilapia can cost about only US\$2/kg in rural areas, meat and poultry can cost US\$4/kg. Hence, tilapia being a cheap source of fish protein can be included in diets for the vulnerable population for enhanced nutritional balance. It can be used in children and infant formula, and be given to pregnant women and nursing mothers, the infirmed, and the elderly.

3.5 Communication

The tilapia farming business is presently not constrained by communication problems. Business transactions can be conducted online. However, the transportation of live tilapia by roads from one part of the country to the other can be traumatic for fish, especially if the consignment of fish needs to reach the destination alive. The road network is poorly maintained, especially most rural and farm roads, and tilapia is vulnerable to transportation over long distances, as they are not as hardy and tolerant as catfish (Haylor, 1989). Without proper handling, mortality can be 100 percent in just six hours of transport.

3.6 Education and training

Regular (hands-on) trainings, workshops and seminars on fish farming by different groups, including the government, universities, research institutes, private extension service providers, and local and international non-governmental organizations, have been organized. However, it is only very recently that dedicated training and human capital development has focused on tilapia farming. Government officials and extension agents are regularly sent for training in tilapia farming, among other aquaculture capacity development programmes, to China, Egypt, the Philippines, Thailand, and other Asian countries under the South-South cooperation as well as bilateral agreements. Exchange visits are also regularly arranged and sponsored between fish (including tilapia) producers and processors in Nigeria and foreign counterparts in order to compare notes and take advantage of recent and advanced technologies.

Facilities exist for training in tilapia and catfish aquaculture for core personnel required for the aquaculture industry, including senior aquaculturists, technicians and extension workers. Four fisheries-related institutes that provide training of senior aquaculturists are: (i) the Nigerian Institute for Oceanography and Marine Research in Lagos (southwest); (ii) the National Institute for Freshwater Fisheries Research in New Bussa (northwest); (iii) Lake Chad Research Institute in Maiduguri (northeast); and (iv) the African Regional Aquaculture Centre in Port Harcourt (southeast).

In addition, three fisheries colleges are closely affiliated with these fisheries research institutes. The colleges train students for the award of diplomas. Several universities also train both undergraduate and postgraduate students for degrees in aquaculture. Their outdoor facilities for both tilapia and

catfish culture research and production have been upgraded and strengthened. All these institutions offer vocational training for technicians, extension agents and farmers. With these institutions having responsibility for tilapia and catfish aquaculture research, there is generally a broad range of aquaculture research skills in Nigeria.

3.7 Aquaculture professional organizations and stakeholders

Organizations for both professional fisheries and aquaculture operators exist, which serve as avenues for the exchange of scientific and technical information, as well as pressure groups to encourage and influence favourable government policies on fisheries and aquaculture development. Professionals are members of the Fisheries Society of Nigeria, while aquaculture operators belong to the Nigerian Association of Fish Farmers and Aquaculturists. Specifically, catfish farmers belong to the Catfish Farmers Association of Nigeria, but for tilapia farmers there is no such organization. The growth of the aquaculture industry has given birth to cooperative societies and consultancy firms to assist operators in the sector. The Tilapia Aquaculture Developers Association of Nigeria was formed in 2014 and held its first annual general meeting in May 2016.

3.8 Environmental impacts

Tilapia farming, at the present level, does not exert substantial negative environmental impacts in Nigeria. Nonetheless, because of intensive culture in cages, concrete tanks and water recirculation systems, problems regarding local pollution of soil and water from effluent discharges may become serious. However, there are laws and regulations by the Ministry of Environment, such as the Environmental Impact Assessment Decree of 1988, that guide the establishment of major agricultural projects that are likely to have substantial impacts on the environment. It would therefore become imperative that best management practices are ensured at every stage of the tilapia value chain.

4. CHALLENGES AND THE WAY FORWARD

Nigeria imports over a half million tonnes of fish annually, which is valued at nearly US\$1 billion, to fill the gap between domestic fish supply and demand (FDF, 2012). This massive importation of frozen fish in the country has ranked Nigeria the largest importer of frozen fish in Africa. The huge sum of money that Nigeria spends annually in fish importation could be used to invest in aquaculture. Nigeria can substitute fish importation with domestic production to create jobs, reduce poverty in rural areas where 70 percent of the population lives, and ease the balance of payments.

Nigeria has the capacity to attain fish self-sufficiency if the numerous aquaculture potentialities that abound in the nation are adequately utilized. Nigeria has 1.7 million ha of land and 14 million ha of water surface. These resources can be utilized to produce an estimated 2.5 million tonnes of fish annually (FDF, 2012). The performance of catfish farming indicates that given a conducive environment aquaculture can thrive in Nigeria. Likewise, there is considerable potential for achieving Nigeria's objectives in increasing fish protein production through tilapia farming. However, various challenges need to be addressed in order to realize the country's great potential in tilapia farming.

High feed cost is a major constraint to the development of tilapia farming in Nigeria. Reliance on expensive imported feed would not be sustainable. Local production of aquafeed tailor-made for tilapia farming is needed. Seed production would also need to be improved. Reliance on the wild collection of seed or imported broodstock would not be sustainable in the long run. Local capacity in producing monosex fingerlings should be developed. The promotion of commercial farming of monosex (all male) tilapia, using genetically improved strains, will significantly boost supplies.

The level of investment in tilapia farming is still low compared with investment in catfish farming, which accounts for over 90 percent of new investments in fish farming. This is because not much attention has been put into profitable tilapia farming, for example, the cage culture of a monosex

variety. This can, however, be addressed by aggressively encouraging and assisting the private sector to invest in viable tilapia projects. Removal or reduction of taxes on inputs for aquaculture in general will likely attract more investors into tilapia farming.

Government, international organizations, development agencies and private donors should help create a conducive environment for the development of tilapia farming. Tilapia aquaculture should be recognized as a priority sector for investment and properly represented in rural development programmes. There is a need to develop well-defined, realistic budgets to implement strategies and plans related to aquaculture. The government should provide the necessary infrastructure, especially rural roads, to facilitate a conducive operational environment. As recommended by Afolabi and Fagbenro (1998), a national aquaculture fund could be established to facilitate fish farmers' access to credit (e.g. helping guarantee loans through cooperatives).

There is a need to establish a Tilapia Centre of Excellence for training with qualified staff that have practical experience in various aspects of tilapia production and utilization. This can be established through public-private partnerships. Regional networks of multidisciplinary training and research programmes could be established to facilitate adaptive research and knowledge-sharing regarding tilapia aquaculture, as well as training core aquaculture personnel. It is important to get the right and qualified people for jobs in tilapia production technology. Applied research should be enhanced to strengthen tilapia production and management systems. More financial support should be provided for research institutes with focus on applied research in all aspects of the tilapia value chain. Government, international organizations and other stakeholders should support pilot scale or model projects to test the technical feasibility and economic viability of tilapia aquaculture systems.

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V. SOCIAL AND ECONOMIC PERFORMANCE OF TILAPIA FARMING IN UGANDA

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ACKNOWLEDGEMENTS

The authors wish to thank the fish farmers in Uganda who opened their doors to researchers and shared the benefits and challenges they face in their aquaculture businesses. The authors acknowledge the constructive input provided by the editors to this report. Funding support of this research provided by the AquaFish Innovation Lab, United States Agency for International Development, is acknowledged.

1. AN OVERVIEW OF AQUACULTURE DEVELOPMENT IN UGANDA

Uganda is a landlocked country in Eastern Africa bordering Kenya to the east, the United Republic of Tanzania to the south, Rwanda to the southwest, the Democratic Republic of the Congo to the west and South Sudan to the north. It has a surface area of 241 038 km² with about 18 percent covered by open waters and 3 percent by swamps. This offers enormous potential for aquaculture and fisheries development, as the sector contributed about 12 percent of agricultural GDP and 2.5 percent of GDP and provided a livelihood to 3.5 million people, who make up 4 percent of the population (Mulonde, 2013; MAAIF, 2012). Uganda has five major inland lakes out of about 165 lakes, which, together with the Nile River, are responsible for most of the capture fisheries production. The lakes, namely Lake Victoria, Lake Albert, Lake Kyoga, Lake Edward and Lake George, contribute 80 percent to Uganda's capture fisheries production. Lake Victoria accounts for about 58 percent of the total catch for the important export species, Nile perch and Nile tilapia. Main rivers in Uganda include the Victoria Nile, Albert Nile, Achwa River (called Aswa in South Sudan) and Kazinga Channel (Keizire, 2006).

Existing records indicate that aquaculture in Uganda started in 1941 after common carp (*Cyprinus carpio*) was introduced to the country from Israel by the colonial authorities with the aim of stocking fingerlings in the relatively colder waters of Lake Bunyonyi in southwestern Uganda (MAAIF, 2012; FAO, 2005) and at the National Fisheries Resources Research Institute (NaFIRRI) – Kajjansi Fish Experimental Station. The introduction of common carp led to disagreements among scientists on the possible impacts of the introduced species on the indigenous aquatic environment in case they escaped from their confines. In the end, a decision was made to use Nile tilapia for stocking purposes. A vigorous fish farming extension programme resulted in the construction of 1 500 ponds by 1956, mainly in the central (Buganda) region and in the most southwestern part of the country – Kigezi (FAO, 2005). During the 1959–1960 period, FAO supported a comparative evaluation programme of carp and tilapia and endorsed the use of carp, which resulted in further expansion of aquaculture in Uganda. Aquaculture was further promoted as part of rural development programmes, and by late 1968 the Department of Fisheries Resources recorded 11 000 ponds, with most of them producing at the subsistence level. This period was followed by changes in policies under successive governments, which led to ad hoc support to the industry. Donor support to aquaculture was suspended because of the unstable political environment, which disrupted research activities on fish culture. Many farmers who had depended on donor support pulled out of fish farming owing to the lack of stocking materials, limited technical guidance and excessive government regulatory regimes. It was estimated that in 1999, Uganda had 4 500 functioning ponds with only a portion stocked and producing 285 tonnes of fish annually (FAO, 2005).

With increasing recognition of the potential contribution of aquaculture to nutrition, food security and employment, aquaculture development in Uganda resumed momentum in 2000, boosted mainly by strategic interventions from the government and support from development partners. Aquaculture activities increased with 20 000 ponds (average size of 500 m²) and 1 500 tonnes of production recorded in 2005. The pond surface area increased to an average of between 50 m² and 200 m² for subsistence farmers and to about 7 000 m² for commercial farmers. It was estimated that in the early 2010s annual aquaculture production from 25 000 earthen ponds (10 000 ha) reached 100 000 tonnes (MAAIF, 2012).

Aquaculture production systems used in Uganda include earthen ponds, cages in reservoirs and tanks. The use of earthen ponds dominates production. Although fish farming in Uganda has been dominated by pond culture, there is a growing interest in commercial cage culture in lakes, water reservoirs and dams (Rutaisire, 2007). Tilapia is increasingly being grown in cages,¹ which are cheaper to build and operate than ponds. Yet information on the locations and production of tilapia cage culture is generally lacking. While support from the government has led to high enthusiasm for cage

¹ Large-scale cage farming in Lake Victoria includes Source of the Nile, Ugachick Poultry Breeders and the National Fisheries Resources Research Institute.

aquaculture, its development is constrained by the lack of quality feed, seed and management skills. While a few farmers practice aquaculture in tanks, mainly at the backyard, the system is not popular because of limited technical know-how and/or access to electricity. Farmers in general seem to be reluctant to engage in intensive fish farming because of the various constraints, such as the lack of and high cost of quality seed and feed.

Tilapia is a good farming species for Uganda with good growth characteristics; it is easy to breed and has a pleasing taste. One drawback is its prolific reproduction and the resultant stunting (FAO, 2005). This has made it less preferred than catfish by many farmers. However, increasing availability and use of monosex fingerlings has helped mitigate the problem. Tilapia requires relatively high water temperature (greater than 28 °C) to achieve optimal growth. This makes it unfavourable for farming in relatively cold places such as the Kigezi region (Kiirya, 2011).

This report provides an overview of the tilapia subsector in Uganda. It includes an analysis of social and economic issues regarding production, consumption and economic performance of the subsector using both secondary (published and unpublished) materials and survey data collected in 2014.

2. TILAPIA VALUE CHAIN IN UGANDA

2.1 Production

According to FAO statistics,² farmed tilapia production grew rapidly from 600 tonnes in 2000 to about 50 000 tonnes in the early 2010s (Figure 1). The production in 2000 was composed of 400 tonnes of Nile tilapia (*Oreochromis niloticus*) and 200 tonnes of redbelly tilapia (*Tilapia zillii*), whereas in the early 2010s production was solely Nile tilapia.

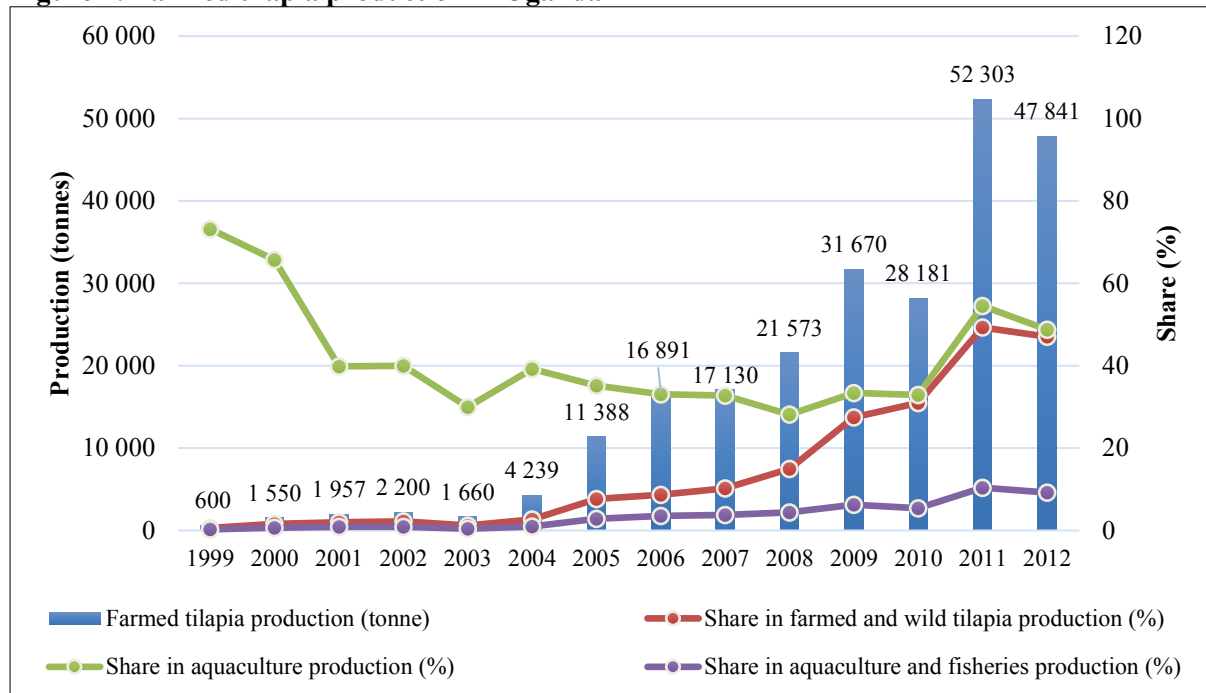
The share of farmed tilapia in total (farmed and wild) tilapia production increased from less than 1 percent in 2000 to nearly 50 percent in the early 2010s (Figure 1). This resulted from the rapid growth of farmed tilapia production as well as the decline of wild caught tilapia production, estimated at nearly 100 000 tonnes in the early 2000s to about 50 000 tonnes in the early 2010s.

Despite the rapid growth in tilapia (wild and farmed), the share of farmed tilapia in aquaculture production declined from over 50 percent in the early 2000s to about 30 percent in the late 2000s. This reflects the faster growth in farmed catfish (*Clarias gariepinus*) production from 120 tonnes in 2000 to about 60 000 tonnes in the late 2000s. The share rose back to about 50 percent in the early 2010s because of the continuing growth of farmed tilapia production and the slight decline in farmed catfish production to less than 50 000 tonnes in 2013.

Besides tilapias and catfishes, a variety of other species have once been farmed in Uganda (including *Cyprinus carpio*, *Labeo victorianus*, *Lates niloticus*, *Macrobrachium rosenbergii*, and *Barbus altianalis*), but only common carp (*Cyprinus carpio*) appeared in the FAO statistics of aquaculture production in Uganda in 2013 (a little over 700 tonnes).

The share of farmed tilapia in total (farmed and wild caught) fish production increased from less than 0.5 percent in 2000 to nearly 10 percent in the early 2010s (Figure 1). Capture fisheries in Uganda supplied over 400 000 tonnes of fish in 2013, including carps (41 percent), Nile perch (22 percent), Characins (19 percent), tilapias (13 percent) and various catfish species (2 percent).

² Unless specified otherwise, the figures presented in this subsection are based on the FAO statistics.

Figure 1: Farmed tilapia production in Uganda

Source: FAO. 2015. Fishery and Aquaculture Statistics. Global production by production source 1950–2013 (FishStatJ).³

2.2 Seed and feed

For the purpose of providing quality fish seeds and extension services, four regional hatcheries and demonstration centres were established by the government, in Mbale, Gulu, Kajjansi and Bushenyi. Yet only the one in Kajjansi remains functional at the time of this writing.

At one time there were over 50 private hatchery operators in the country with good hatchery facilities and capacity to produce quality seeds (tilapia or catfish) for supply and distribution (MAAIF, 2012). However, not all of the private hatcheries are active, and most of the active ones are concentrated in the east and central regions. This has resulted in a shortage of quality fish seed supply in other districts with potential in aquaculture (e.g. the northern region).

A review of global tilapia farming practices indicates that the cost of feed ranged from 34 percent to 87 percent of the total cost in East Asia (Gupta and Acosta, 2004). Hyuha *et al.* (2011) reported that feed constituted 25 percent of the production cost of tilapia aquaculture in Uganda.

MAAIF (2000) indicated that most fish farmers in Uganda used on-farm resources such as green leaves, kitchen wastes and chicken droppings to feed their fish, and some farmers (about 30 percent) used feed ingredients such as maize or rice bran or oilseed cake to feed their fish. Rutaisire (2007) observed that commercial farmers used commercial and/or farm-made feeds, whereas subsistence farmers relied on organic fertilization of ponds and provision of green leafy products regardless of whether the fish are herbivorous or not. Some farmers made their own feeds using formulas provided by Kajjansi Aquaculture Research and Development Centre (MAAIF, 2012).

Availability of floating feed is a critical requirement for the development of commercial aquaculture in Uganda (Olwo, 2009). The commercial feed industry for aquaculture in Uganda is still in its infancy. A major aquafeed producer, Ugachick Poultry Breeders (Ugachick in short), produces

³ In FAO Fisheries and Aquaculture Department [online or CD-ROM]. Rome. Updated 2015. www.fao.org/fishery/statistics/software/fishstatj/en.

floating aquafeed for commercial purposes. The company supplies feeds to domestic farmers and also to neighbouring countries such as Kenya; the supply is usually not enough for both domestic and regional markets. NaFIRRI started to produce sinking feed in 2011, and its supply is also not enough for the domestic market. A major challenge faced by aquafeed producers is the limited supply of a main ingredient, *rastrineobora* (mukene), which is also demanded by poultry producers and for human consumption.

2.3 Processing and trade

In Uganda, fish for domestic consumption could be sold directly at farmgate, or through a longer value chain, from grow-out farmers, to intermediaries, to processors, to retailers and then to consumers, or from grow-out farmers or farmer groups, to processors and then to regional markets (Bukenya, Obuah and Hyuha, 2012; Ssebisubi, Knutsson and Gestsson, 2012).

Fish for export could go through more complicated value chains. For example, a typical value chain of wild-caught Nile perch goes as follows (Atukunda and Ahmed, 2012). Fishers sell their fish to intermediaries who sell it to agents and fish processing plants. Specifically, transporter boats operated by intermediaries buy fish from fishers in remote landing sites and then sell it to the main landing sites approved by processing factories. At the approved landing sites, prime quality fish is sold to factory agents and what is left is sold to fishmongers and later sold in domestic markets. Vehicles equipped with cold storage equipment or containers with packed ice are used to transport the fish to the local markets. The trader/fishmonger normally bears the costs of transport. The members of an association, such as the Walimi Fish Farmers' Cooperative Society (WAFICOS), may call on the association for assistance in marketing.

Fish traders generally deal with many fish species including tilapia, and there is no specified market for cultured tilapia (Bukenya *et al.*, 2012). In a recent study by Hyuha *et al.* (2011), traders surveyed in central Uganda revealed that they concentrated more on captured fish, which provided higher margins. The gross margin obtained from selling Nile perch could be US\$1.72 per kg of fish, much higher than that for tilapia (US\$0.61) (Hyuha *et al.*, 2011). Bukenya *et al.* (2012) reported that most of the farmed tilapia were sold at the pond side. The lack of infrastructure such as cold facilities has been a major constraint on value chain development for both wild and farmed tilapia. With the support of a donor-funded project, WAFICOS acquired a refrigerated van and set up a collection centre to help tilapia and catfish farmers sell fresh produce to consumers. Unfortunately, the service was disrupted after the van was ruined in an accident.

Currently, there are eight major fish processing companies, all of which are members of the Uganda Fish Processors and Exporters Association. These companies process mainly Nile perch or other wild-caught fish for export to various destinations, including the European Union, Middle East, the Republic of Korea, and Singapore, among others.

It has been reported that because of the declined fish supply from capture fisheries, some fish processing plants have been shut down and the remaining ones generally operate below their full capacity (FAO, 2012). One major issue is that fish are often of poor quality and hence unfit for the international market. It is estimated that 60 percent of fish supply in Uganda does not meet export standards, especially those demanded by European Union markets (MAAIF, 2012). Major contributing factors to this situation are bad practices such as harvesting undersize fish, using illegal fishing gear and unauthorized fish trading. A National Fisheries Taskforce has been established to control illegal fishing and other practices, and communities have been increasingly involved in managing their own resources. However, in the authors' opinion, a long-run solution lies in increasing fish supply through intensive aquaculture production.

During the late 2000s and early 2010s, Uganda's average annual fish export was 24 000 tonnes (UBOS, 2013), which was much lower than its fish production. Regional exports accounted for about 10 000 tonnes per year, 55–60 percent of which went to the Democratic Republic of the Congo,

30–35 percent to Kenya, and the remainder to the Sudan (former). A study in 2008 that traced informal exports of fish from Uganda to neighbouring countries (MAAIF, 2012) indicated that 12 466 tonnes of fish went from Uganda to the Democratic Republic of the Congo, 5 381 tonnes to Kenya, and 5 404 tonnes to the Sudan (former).

The main export species include mukene (*Rastrineobola*), *Clarias*, tilapia and Nile perch. The main export products include chilled and frozen Nile perch (*Lates niloticus*) and tilapia (*Oreochromis niloticus*) in various product forms, such as whole gutted, skin on or skinless, fillets, air bladders (fish maws), fish heads, steaks and loins (FAO, 2012).

Most of the farmed tilapia or farmed fish in general are sold directly to consumers at farmgate, whereas some farmed fish are sold in marketing centres (MAAIF, 2012; MAAIF, 2000; Hyuha *et al.*, 2011). Some fish farmers or traders process farmed fish by salting, sun drying or smoking to serve distant and bigger markets. There is only one firm in Entebbe known for exporting cold-smoked catfish internationally (MAAIF, 2012).

Uganda's formal export of farmed tilapia is limited. A large company, Source of the Nile, sells some of its farmed tilapia production to Rwanda and South Sudan. Some large companies export catfish to the Democratic Republic of the Congo. Data on the processing of farmed tilapia are also limited because fish farmers in Uganda usually do not keep detailed or accurate records about their business activities. Tilapia export from Uganda is usually informal and oftentimes unrecorded.

As noted earlier, because of the reduction in Nile tilapia catches from the wild, some fish processors sign contracts with tilapia farmers to maintain the supply of raw materials. Some processors have started cage farming on lakes to grow Nile tilapia for filleting and export owing to the high demand for tilapia fillets in the United States of America and European markets (SON, 2013).

Uganda has been trying to develop certification procedures and regulations in order to facilitate exporting aquaculture products to foreign countries. For exports, food safety relating to fisheries products is addressed in the EC Directive 91/493 of 1991. This directive deals with production and marketing of fishery products for human consumption. According to the directive, Uganda had to establish a system for inspection and control to ensure the safety of fisheries products, including the implementation of good hygienic practices and the Hazard Analysis Critical Control Point (HACCP) system. Other regulations controlling the export of fisheries products are the EC Regulation 466/2001, which sets the maximum limits for heavy metals in a number of species of fish and shellfish, and EC Regulation 2065/2001 on labelling information of fisheries and aquaculture products (Ponte, 2007).

2.4 Consumption and price

Fish is one of the most important animal protein sources in Uganda. According to data provided by the FAO food balance sheet, fish contributed more than 30 percent of the country's animal protein intake in the early 2010s, which was higher than beef, mutton or poultry.

The survey data reported by MAAIF (2000)⁴ indicated that 37.4 percent of Ugandan households ate fish, which was twice more than the households that ate beef (17.9 percent) and milk (17.4 percent). Fish consumption was most popular in the West Nile region (52.1 percent), followed by the central region (40.8 percent), the east region (36.3 percent), and the west region (20.3 percent). Tilapia is the most preferred fish species in Uganda, consumed by over 80 percent of households surveyed in MAAIF (2000), higher than Nile perch (about 60 percent), *Rastrineobola* (about 30 percent), *Clarias* (about 20 percent), and several minority species (10 percent or less) such as *Protopterus*, *Alestes*,

⁴ The baseline survey in 1999–2000 by the Ministry of Agriculture, Animal Industry and Fisheries and the Kajjansi Aquaculture Research and Development Centre was carried out in 42 districts covering 3 293 respondents (including 901 fish farmers).

Bagrus and Hydrocynus. Ugandans who are closer to waterbodies such as Lake Victoria (central region) and Lake Albert and the Nile River (West Nile region) have more access to and a cultural tradition of consuming fish (FAO, 2012).

In addition to access and income factors, culture could play a major role in fish consumption patterns. For instance, in the past, in areas where livestock production was predominant, there were taboos associated with eating fish. It was believed, for example, that eating fish would affect the milk yields of animals. However, such cultural traditions have been gradually changing because of migration, cross-cultural marriages and nutritional awareness campaigns carried out by the Ministry of Agriculture, Animal Industry and Fisheries and the Ministry of Health.

Fish reaches Ugandan consumers in various sizes, shapes, states and quantities. The main species in markets are Nile perch, catfish and tilapia. Nile perch found in local markets is either fresh, sun dried or smoked, but there are also sun-dried juveniles and by-products such as frames and skins as well as fish balls and cakes made from scraps. Tilapia is sold live, smoked and fried. There is usually no distinction between cultured and wild tilapia on the market. A common view is that few consumers can make the distinction, but there are no systematic market studies to confirm this.

Boiled and/or fried are the most common ways of preparing fish dishes in Uganda. Households in the central region appeared to prefer fried and boiled fish the most, boiled the second, and fried the third, whereas those in the east or west regions prefer boiled fish over the other two styles (MAAIF, 2000). In the north region and the West Nile region, which are the main growing regions of simsim (sesame) and groundnuts, smoked or sun-dried fish cooked with simsim or groundnut paste were the most popular fish dishes (MAAIF, 2000).

While the average farmgate (or first-sale) price of tilapia during 2006–2010 appeared to be similar to Bagrus, lower than African catfish and Nile perch and higher than mukene, the tilapia farmgate price in 2010 appeared to be only lower than the Nile perch and higher than the other three (Bjørndal, Child and Lem, 2014). Field surveys by the authors revealed that there has been a tremendous increase in fish prices irrespective of the source (farmed or captured). Whereas in 2009 large tilapia (500 grams and over) cost between US\$ 6 000 and US\$ 7 000 per kg (US\$2.44–US\$2.85), in 2013 it was priced at about US\$ 12 000 per kg (US\$4.88). The tilapia farmgate price also increased from US\$ 3 000 to US\$ 4 000 per kg (US\$1.22–US\$1.63) in 2009 to US\$ 7 000 (US\$2.85) in 2013. Because of the high prices, the consumer preference seems to have shifted from large-sized fish (500 grams) to small-sized fish (< 250 grams) due to affordability (Olwo, 2009; Hyuha *et al.*, 2011).

3. ECONOMIC PERFORMANCE OF TILAPIA FARMING

Assessment of the economic performance of tilapia farming in Uganda in this section is based primarily on data and information from a survey conducted by the lead author in February 2014 and a study on promoting commercial aquaculture in Uganda commissioned by the European Union Delegation in Uganda (2011). The February 2014 survey covered major fish farming districts in eastern Uganda (Sironko and Manafwa) and central Uganda (Mukono, Wakiso and Mpigi). Among others (e.g. catfish farmers), 40 small-scale farmers engaging in tilapia monoculture were interviewed in the survey. In the 2011 European Union (EU) study, the potential of a 10 ha fed, green pond system was examined based on the experience in Uganda.

3.1 Farming systems and technologies

A variety of aquaculture systems exist in Uganda, including pond culture, cage/pen culture and tank/raceways culture (MAAIF, 2012). Pond culture was introduced in the 1950s soon after the establishment of the Uganda Game and Fisheries Department and the construction of the Kajjansi Fish Experimental Station (Jagger and Pender, 2001), and has become the most common system in the country. A typical pond is either an excavated ditch built on relatively flat ground with a water basin

and surrounded by raised ground or is a contour type built in a shallow valley with a water basin formed with a single dyke (dam) across the valley. In contour ponds, the shape, depth, size and bottom are dictated by the nature of the valley and are difficult to manage because of the irregular shape, excessive depth and uncontrollable water supply (NAADS, 2005).

In cage systems, fish are grown in a closed net structure fixed into a large waterbody such as a lake, river and dam. Cage production is practised mainly by private commercial companies, and there is high enthusiasm for it among local fish farmers. Production from cage aquaculture is expected to rise as farmers are seriously considering cage farming initiatives because of the availability of water resources and materials for construction and readily available pelleted fish feed (MAAIF, 2010).

Tank aquaculture involves fish production in completely intensive power or gravity-driven systems, and their requirement for technical design, materials and energy has rendered it expensive in Uganda.

3.2 Capital investment

Most fish farmers in Uganda are small-scale farmers with inadequate capital to finance farming operations. The average pond size of the 40 farmers interviewed in the February 2014 survey was 531 m². This is consistent with the finding in Bukenya *et al.* (2013). Pond construction cost was usually the only initial investment cost incurred by tilapia farmers. The average pond construction cost was US\$2.04/m².⁵ Lending rates by financial institutions ranged between 20 and 25 percent per year, which hindered small-scale farmers from obtaining credit to purchase equipment such as pumps and generators.

The 2011 EU study showed that a 10 ha, pond-based farm could entail US\$230 000 to establish, including about US\$200 000 for pond construction (US\$2/m²), US\$15 000 for a diesel powered pump for water supply, and other investments in facilities such as stores, workshops and canteen buildings.⁶ The study pointed out that pond construction costs could vary widely according to various factors such as topography, soil type and pond dimensions – a hand-dug pond could cost around US\$2/m², and using machinery to construct a large pond (e.g. 10 ha) could cost less than US\$2/m².

3.3 Seed

The average stocking density for the interviewed tilapia farmers in 2014 was about 2.5 fish/m²; the average price of tilapia fingerlings was US\$0.12 per piece. On average, 1 319 tilapia fingerlings were stocked in a 531 m² pond and farmed for eight months to table size. The number of fish harvested was 916, which implies about a 70 percent survival rate.

The 2011 EU study indicated that sex-reversed tilapia fingerlings (15 grams) could cost US\$0.1 per piece. The size of the fingerlings could reach 550 grams after eight month in a fed, green pond system, and a 10 ha farm could produce 100 tonnes of tilapia in one cycle.

3.4 Fertilizer and feed

Fish yields have been found to significantly increase when fish ponds are appropriately fertilized and fed (Hazell, Jagger and Knox, 2000). Subsistence fish farmers in Uganda often fertilize their ponds with various types of home-made organic fertilizers such as cattle, goat or chicken manure. It is generally applied at 20 kg per 100 m² (Rutaisire, 2007).

According to the 2014 survey, the average farmer with a 531 m² of pond size used 90 kg of fertilizer in an eight-month production cycle (meaning 1 695 kg/ha per cycle), costing US\$79/ha per cycle at the price of US\$0.046/kg. The average farmer used 268 kg of feed in the eight-month cycle, including

⁵ The exchange rate used to convert the results of the February 2014 survey is US\$1 = 2 455 USH.

⁶ The exchange rate used in the European Union report is US\$1 = 2 300 USH.

82 kg of home-made feed and 186 kg of purchased feed. The average price of the purchased feed was US\$1.02/kg.

According to the 2011 EU study, a fertilized pond system (10 ha) could use chicken manure at a rate of 50 kg/ha per week (meaning 1 714 kg/ha per eight-month cycle), which would cost US\$124/ha per cycle at the price of US\$0.072/kg. A fed, green pond tilapia farming system (10 ha) could use floating pellets at the average price of US\$0.52/kg and result in a feed conversion ratio (FCR) of 1.8.

3.5 Labour

Fish farming is a labour-intensive activity that involves pond construction and maintenance, feed collection (for example, maize, bran and dried mukene), collection of manure, fertilization and protection of ponds. In addition, labour is also required in harvesting, processing and marketing of fish (Nyombi and Bolwig, 2004; Jagger and Pender, 2001). Labour could represent a high proportion of total production cost in the Eastern Africa region. Evidence from Rwanda shows that small-scale aquaculture cooperatives and individual fish farms have very high labour requirements compared with other agricultural enterprises (Hishamunda, Jolly and Engle, 1998; Hyuha *et al.*, 2011).

The total labour cost for the average tilapia farmer (531 m²) in the 2014 survey was US\$243 per eight-month cycle, implying US\$4 580/ha per cycle. Specifically, the labour cost included US\$93 for two security persons, US\$37 for one technical consultant, US\$64 for a manager, US\$45 for harvesting, and US\$4 for transport to market. The labour used for harvesting included 25 person-hours of family labour (five people and five hours/person) and 12 person-hours of hired labour (six people and two hours/person). The cost of hired labour for harvesting was US\$1.22/hour. The labour used for transport to market included 4 person-hours of family labour (one person and four hours/person) and 1 person-hour of hired labour (one person and one hour/person). The cost of hired labour for transport was US\$0.81/hour.

According to the 2011 EU study, the total labour cost of the 10 ha fed tilapia pond system was US\$41 600 per eight-month cycle, implying US\$4 160/ha per cycle.

3.6 Miscellaneous costs

Other materials used in tilapia farming from the 2014 survey include lime (average 1 299 kg/ha per cycle and US\$228/ha per cycle); sampling net (average one for each farm costing US\$92); harvesting net (average one for each farm costing US\$117); trading licence (average US\$99 per farm per cycle); and market dues (average US\$12 per farm per cycle). A trading licence is a form of tax paid to the government (monthly or annually) to obtain permission to operate a business. Market dues is a type of payment made to the management of a market every time a farmer takes fish to the market to sell. Markets are tendered out by the government to individuals or companies who would collect the market dues.

In the fed tilapia pond system presented in the EU study, miscellaneous costs included US\$600/ha per cycle of fuel cost for the diesel powered pump and US\$1 000/ha per cycle of other unspecified costs.

3.7 Productivity and profitability

The average farmer in the 2014 survey with a 531 m² of pond size harvested about 916 pieces of table-sized fish. The farmers usually sold their product by number, but the exact weight of the harvest is unknown. As mentioned above, the average farmer used 268 kg of feed. If the FCR was 1.5, then the harvest would be 179 kg, implying about 200 grams per fish and 3.4 tonnes/ha per cycle. If the FCR was 2.0, then the harvest would be 134 kg, implying about 150 grams per fish and 2.5 tonnes/ha per cycle.

The total operational cost for the average farmer was US\$1 011, including US\$657 of material costs (e.g. seed, feed,⁷ fertilizer, lime and nets), US\$243 labour cost⁸ (e.g. security, technical consultant, manager, harvesting and transport), and US\$111 for taxation or fees. With the pond construction cost of US\$2.04 per m², the average farmer's investment cost for building a 531 m² pond was US\$1 083, which implies US\$54 of capital cost per cycle under the assumption of a 20-cycle depreciation period. Therefore, the total cost (i.e. operational cost plus capital cost) would be US\$1 065 per cycle.

If the harvest was 179 kg with an FCR of 1.5, then the average farmer would need to sell the product at US\$5.95/kg in order to break even (i.e. revenue from selling the product being equal to the US\$1 065 of total cost). If the harvest was 134 kg with an FCR of 2.0, then the break-even price would be US\$7.95/kg. It is important to note that these are specific results based on the 2014 survey, which may not reflect the overall profitability of small-scale aquaculture in Uganda. Further study in this area is needed.

The 10 ha fed tilapia pond system presented in the EU study was expected to produce 100 tonnes of 550 gram fish in an eight-month cycle, implying 10 tonnes/ha per cycle and an FCR of 1.8. The expected total cost was US\$196 980, including US\$93 913 of feed cost, US\$33 967 of seed cost, US\$6 000 of energy cost, US\$41 600 of labour cost, US\$10 000 of other costs, and US\$11 500 of depreciation cost. Thus, the break-even price would be US\$1.97/kg for the 10 ha fed tilapia pond system.

4. SOCIAL PERFORMANCE OF TILAPIA FARMING

4.1 Food security and nutrition

Tilapia is a source of high-quality protein and other essential nutrients (SON, 2013). About 34.5 million Ugandans derive their animal protein from fish (MAAIF, 2012). About 80 percent of rural communities in Uganda rely on fish as the main protein source (IUNR and ARDC, 2010). Consumption of fish would help reduce child mortality and improve the resistance of children to diseases (Isyagi, 2007). Tilapia is low in fat and calories and a source of fatty acids, which makes it an important meal for mothers and growing children (Beveridge, 2013; UNEP and NEMA, 2004). Tilapia is fast maturing, easy to keep, and the most popular fish with farmers and consumers; thus, its demand locally and internationally is enormous (ACP-EU, 2007). In Uganda, tilapia is the most suitable farmed fish owing to its omnivorous feeding habits. Many people refer to it as a fish of the future.

4.2 Employment and income

The total population of Uganda is about 35 million people (UBOS, 2012), out of which about 12 000 farmers are involved in aquaculture and some 150 aquaculture service providers employed by the local government (MAAIF, 2012). The fisheries sector also employs a significant number of men and women who are involved in fish processing and trade in domestic, regional and international markets. Auxiliary industries, such as packing, manufacturing of fishing nets, and the transport and fuel industries, also provide jobs to the population at different parts of the value chain (Keizire, 2006).

About 1 million to 1.5 million people are directly or indirectly employed in fisheries-related activities, with about 5 000 people working in industrial processing. The fisheries sector contributes to the livelihoods of about 5.3 million people. Over 1.2 million people are directly dependent on the fisheries sector as the main source of household income (MAAIF, 2012). Tilapia farming provides employment opportunities along the entire value chain. They range from farm labour to management,

⁷ The price of purchased feed is used to calculate the imputed value of home-made feed.

⁸ The price of hired labour is used to calculate the imputed value of family labour.

pond constructors, pond diggers and operators, and sellers of fingerlings and mature fish (FAO, 2005). Fishmongers, processors and other key industry workers also benefit from tilapia farming.

Most of the fish farmers have commercial interests and reasonably large families that provide labour, or have the ability to hire labour. Fish farmers are generally willing to use technical assistance from private service providers and to pay for quality fish seed from specialized private commercial hatcheries.

Most of the fish farmers in Uganda are smallholder farmers. In Kampala alone, out of the 28 fish farms surveyed in 2007, 18 farms were involved in tilapia and catfish farming and 10 involved with hatchery production (Isyagi *et al.*, 2009). In a study carried out in June 2010 in the three districts of Wakiso, Mpigi and Mukono in central Uganda, 82 percent of the 200 small-scale fish farmers reported activities in tilapia farming (Bukonya *et al.*, 2013).

4.3 Gender

In fisheries, women often dominate in trading and processing activities (e.g. smoking, salting and sun drying). They buy fish from farmers or landing sites for processing and sell to consumers (Keizire, 2006). When fish farming was introduced in Uganda, it was assumed that men would have control of the sector as they were perceived to be the “owners” because they owned the land through the inheritance system. This perception has implications on extension services offered. Even though women manage their husband’s farms, extension agents would talk only to men. The women are often bypassed in training even though they have management skills required to properly manage the ponds (Aganyira, 2005). In spite of the role of women in managing fish farms, they are often not involved in farm decisions relating to construction, pond management, harvesting, marketing, and the sharing of farm proceeds. Men control proceeds from fish farming, just like other agricultural activities, even though both genders participate in farm activities. Increased aquaculture production, therefore, may not necessarily improve women’s livelihoods or welfare, but may on the contrary create additional workloads and be detrimental to their health. A study on the involvement of women along the value chains indicates that women, especially those at the lower end of the social ladder, are more vulnerable to, as well as exposed to, health hazards because they generally work with limited protective gear (Bjørndal, Child and Lem, 2014). Furthermore, programmes aimed at improving incomes may not have the intended positive impact on women who lack landownership.

5. GOVERNANCE AND INSTITUTIONS

5.1 Legal and institutional framework

Tilapia farming and aquaculture in general in Uganda has been governed by the Aquaculture Unit in the Department of Fisheries Resources, which has been upgraded to a fully fledged department of the Ministry of Agriculture, Animal Industry and Fisheries.

The Fish and Crocodiles Act of 1964 formed the basis for aquaculture development. The National Fisheries Policy (2004) replaced the Fish and Crocodiles Act and the Fish (Quality Assurance) Rules of 1998. The National Fisheries Policy provides the basic framework for the operations and the marketing of fish in the country. Other regulations include the Fish (Aquaculture) Rules 2003 (Government of Uganda, 2003), which regulate aquaculture practices, especially at the commercial level.

Aquaculture research is regulated by the National Agricultural Research System Act of 2005, which disrupts the monopoly of public agriculture research by public institutions and opens research opportunities to other interested competent agencies and individuals through competitive research grants. The act regulates fisheries and aquaculture research among other agriculture research areas. This act is intended to encourage competition in sourcing funds and research grants.

Land-based aquaculture activities are also under the jurisdiction of the Land Act of 1995, which regulates land use in pond construction. The Land Act of 1995 spells out the tenure system for landownership and the legal rights of landowners. The act also defines the ownership of wetlands, swamps and other shallow waters. The National Environment Management Authority (NEMA) restricts aquaculture to a distance of 200 m from the shoreline of a wetland and the installation of any water obstruction system to supply the river-fed ponds. The NEMA statute deals with the protection of the environment and regulates all activities that may impinge on the quality of the environment. The water law spells out the use, access, responsibility of user, conflict resolution in water resource use and access to all users including aquaculture practitioners.

Uganda has adopted a fisheries policy that gives guidelines and principles on management of fisheries resources under local and international laws such as the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). There are rules governing aquaculture, including tilapia farming as an enterprise. Private stakeholders seeking to market farmed fish products have to obtain an annual permit from the Department of Fisheries Resources. Permits are required for the transportation of all aquaculture products and are issued by the Ministry of Agriculture, Animal Industry and Fisheries to reduce incidences of harvesting illegal wild catches disguised as aquaculture harvests. A live fish transport permit costs about US\$4 per tonne. The fisheries management regulations include the Fish Act of 1964 for the control of fish and the conservation of fish and all matters of fisheries and fisheries products transactions. To ensure responsible fisheries, food safety and marketing, the rules and regulations are enforced through the issue of permits to stakeholders. These permits cover domestic, regional or international transactions and act as a barrier to enter into or exit from the fishery and specific markets.

In order to enforce these regulations, a National Fisheries Taskforce is in place. The task force is composed of officers from the Department of Fisheries Resources, Uganda Fish Processors and Exporters Association, Uganda Police, Uganda Revenue Authority, and Beach Management Units (MAIIF, 2012). The main objective of the task force is to enforce relevant laws regarding responsible fishing and aquaculture development in the country.

5.2 The roles of the Ugandan government in tilapia farming

The Ugandan government's primary role in tilapia farming is to establish regulatory and policy frameworks within which the subsector works. In this respect, the government is implementing various rules and regulations alluded to the above. The government has put in place the Development Strategy and Investment Plan (DSIP), a policy document that sets the framework for agricultural transformation. The DSIP identifies nine priority commodities for investment by the government. The DSIP is operating in line with the National Development Plan, which sets the priority agenda for Uganda's development. Within the DSIP document, priority is given to aquaculture development as a way to cover the food fish gap created by the declining wild capture fisheries.

The extension system has undergone structural changes. The new policy is that the government is to operate a unified extension system. The Ministry of Agriculture, Animal Industry and Fisheries has regained its authority over the system as it was in the past before it was decentralized. All the district fisheries officers in the country will be reporting to the ministry.

Other government agents may also be involved in promoting fish farming. For instance, the National Agricultural Advisory Services has been mandated to promote commercial farming as a business to fight poverty and malnutrition (Rutaisire, 2004). Similarly, the Uganda Investment Authority encourages large commercial-scale investments in the aquaculture sector by giving tax holidays. In the era of public-private partnerships (PPP), other service providers with known competencies will be mandated to offer such services.

Some of the major hindrances to aquaculture development, as pointed out earlier, are quality seed and feed. The Government of Uganda is therefore supporting NaFIRRI-Kajjansi in terms of human

resources to carry out meaningful research to improve the productivity of fish farming. Under the Forum on China-Africa Cooperation, China set up a US\$5 million fish farming demonstration centre called the China-Uganda Friendship Agricultural Technology Centre, where local farmers are trained in modern ways of fish farming using simple and affordable technologies at NaFIRRI-Kajjansi.

The government is also responsible for coming up with viable policies to boost the development of the aquaculture industry. In this respect, the Government of Uganda has come up with PPP policies, not only for fisheries but also for many other sectors. As the government may not be efficient in conducting business, the Ugandan Government has divested many of its parastatals and focused on providing infrastructure and policies to guide the direction of the sector. The establishment of aquaculture parks is one such effort (Mugabi *et al.*, 2013). An aquaculture park is an industrial estate where aquaculture plots are leased out to investors or aquaculture farmers. The government's responsibilities are to provide technical services and utilities designed to address the current constraints to the development of the sector. The perceived benefits include improved planning and management of aquaculture development, encouragement for the development of small to medium aquaculture production models, cost-savings and economies of scale, and diversification into aquaculture by fishers and rural communities (White, 2012). The aquaculture park policy recognizes the role of PPPs as the most efficient vehicle through which the sector will move from subsistence to commercial aquaculture. However, the success of the policy would require the government to play a key role in identifying and demarcating areas for aquaculture parks, mobilizing and organizing aquaculture production for access and utilization of aquaculture parks and soliciting for bilateral funding.

5.3 The roles of donor-funded projects

According to the report submitted to the European Union Delegation in Uganda (2011), major donor-funded projects that contribute to aquaculture development in Uganda include:

- The small-scale fish farming project funded by the United Kingdom of Great Britain and Northern Ireland (1998–2004), which helped establish the Aquaculture Unit in the Ministry of Agriculture, Animal Industry and Fisheries, the development of aquaculture rules and regulations, the aquaculture survey and feed formulation.
- The aquaculture component of the Lake Victoria Environmental Management Project (1998–2004), which helped develop human capacity (e.g. three studentships for PhD training).
- The aquaculture component of the African Development Bank fisheries development project (2000–2008), which helped refurbish NaFIRRI, including buildings and ponds, and facilitated the study on aqua feeds.
- United States Agency for International Development (USAID) Fisheries Investment for Sustainable Harvest (FISH) project (2005–2008), which helped research and develop new and/or appropriate technologies and training in feed, hatcheries, production, harvesting and transport, contributed to establishing domestic feed production capacity via supporting Ugachick, and helped strengthen fish farmer organizations.
- USAID Livelihoods and Enterprises for Agricultural Development (LEAD) project (2008–2013), which consolidated the FISH project's work with Ugachick, supported hatchery production and improved hatchery and farming practices, and set up clusters of hatcheries, grow-out and markets.
- China-Uganda Aquaculture Project NaFIRRI-Kajjansi (2010–2011), which helped rehabilitate the water supply system and construct offices, hatchery and feed mill.

The interventions have posted mixed results. NaFIRRI-Kajjansi has been the biggest beneficiary, as it has rehabilitated, refurbished and researched new technology on feeds, hatcheries, production and harvesting. The institute has also increased its human resources capacity. The feed sector, albeit still maturing, has started producing floating feeds for both the domestic and international market. Farmer groups have been strengthened and expanded. However, the drawbacks of donor-funded interventions

include a lack of focus, low donor and/or local government's commitment, delay in completion, and inflexible approach, among others (EU Delegation in Uganda, 2011).

5.4 Fish farmers' associations

The aquaculture industry in Uganda is characterized by a large number of small-scale farmers producing less than 1 tonne of fish/ha per year (Ssebisubi, 2011). To improve the sector's performance, fish farmers have formed farmer groups to enable them to market their products and harness economies of scale through hire of equipment and services and bulk purchasing of inputs. Examples are WAFICOS in central Uganda, the Iganga zonal fish farmers in eastern Uganda, and the Kabeihura fish farmers in western Uganda (Isyagi *et al.*, 2009). One of the notable achievements is the farmer's symposium, which is held annually in Kampala and brings together various stakeholders to share and exchange new ideas.

Many farmers' associations (e.g. WAFICOS) have benefited from services provided by the government and development partners. Through WAFICOS, the USAID FISH and LEAD projects supported Ugachick, a WAFICOS member that was already involved in manufacturing poultry feeds, to set up state-of-the-art machinery to manufacture floating fish feeds. Through the same programme, annual symposiums have been initiated to provide a platform for fish farmers, traders, input dealers and policymakers to share experiences, play an advocacy role and disseminate technologies. Farmers' associations such as WAFICOS have been active in lobbying for and securing both public and private services for its members on issues ranging from production to collective marketing and training. The Cooperative Alliance of Uganda is supporting many farmer groups through its fish farming component to alleviate poverty and malnutrition in the country. Member farmers have been given fish seed and extension services in a bid to improve their livelihoods (Tayebwa, 2011).

5.5 Contract farming

While contract farming is a mechanism often used in crop production (e.g. Mukwano Industries for tea, sunflower and palm oil, Lugazi Sugar Works for sugarcane, and Bidco for palm oil), fish farming has not developed to the point of having big companies contracting farmers for the supply of fish. However, one company, Source of the Nile, is planning to start supplying selected inputs such as feeds and, in turn, buying the fish from farmers on a contract basis (SON, 2013). This arrangement is envisaged to help farmers on issues of quality assurance and technical assistance from the company (SON, 2013). Such arrangements involving supplying inputs and market assurance motivates farmers to produce more. Gibbon, Lin and Jones (2009) has shown that contract farming in the case of certification of cocoa and vanilla resulted in an increase of 150 percent revenue for organic farmers. The main benefits of contract farming are to provide farmers with market access, stable prices, and/or access to yield-enhancing technologies.

6. ISSUES, CHALLENGES AND THE WAY FORWARD

Aquaculture development in Uganda faces various issues and challenges. Many of them have risen from the fact that, until recently, the sector was mainly subsistence in nature and received limited assistance from the government and other stakeholders. The government's recent investment in the subsector is because the stocks from captured fisheries have dwindled in the face of rising demand for fish both domestically and internationally. In the early 1950s, government efforts were directed at promoting aquaculture as a sector to provide food fish to its citizens. Fish farming was seen as a new farming system that farmers were not familiar with; therefore, productivity remained low because they lacked appropriate skills. The human capacity to push the sector forward was limited. This can be partly explained by limited attention to the sector in terms of training. Until recently, there was no specific course in aquaculture at public universities such as Makerere University. Before 2000, aquaculture was not a distinct subject but covered as part of a course in fisheries; thus, graduates were ill-equipped to offer extension services to fish farmers. Such marginalization also existed in the

National Agricultural Advisory Services programme, which was meant to resuscitate extension services to the sector and stimulate productivity in agriculture, animal industry and fisheries. Aquaculture fell under the non-theme commodity, implying that it was not supported under Phase I of the Agricultural Technology and Agribusiness Advisory Services Project. Because of this neglect, farmers, especially smallholders having an average of two to three ponds, faced big challenges to obtain reliable quality seed and feed. Access to required finance is another big challenge for fish farmers in Uganda, as many banks are not willing to invest in the sector because it has not demonstrated impressive returns.

The value chain for aquaculture is not as developed as that of other sectors such as the dairy industry. Major actors are not recognized, information flow is limited, and infrastructure to support development of the sector is inadequate. The lack of production standards and food quality and safety assurance systems has prevented farmed fish products in Uganda from attracting favourable prices or even access to regional or international markets.

There is a lack of reliable data on the tilapia industry, stemming from the fact that the old system of administration where district fisheries officers were required to file periodic reports on the sector were abandoned in favour of decentralization. Because of this restructuring, district fisheries officers report to the districts and thus the ministry staff has no authority to demand regular filing of data on the sector. This has resulted in inconsistent information published about the sector, which presents a big challenge to planners and those who might want to utilize the data for intervention purposes. However, the system is being restructured, and the ministry is regaining its authority that it had lost in the past. District fisheries officers will be reporting to the ministry, and they are to be retooled. One challenge is how to obtain data from fish farmers and enterprises. Fish farmers in Uganda often do not keep records, and records kept are often not appropriate or accurate. Creating a database for aquaculture production, especially for tilapia, is urgently required. Countrywide value chain studies on tilapia and marketing are required to generate reliable information to enable policymakers to plan for the sector properly.

In recent years, the government has made tremendous effort in providing a favourable policy environment for aquaculture to flourish. Having realized that it does not have adequate resources to attend to all the demands from different actors in the aquaculture value chain, the government has decided that the best strategy to increase productivity and commercialize the sector is to link up with the private sector through PPPs. The government has partnered with private companies to invest in feeds. It has also appealed to development partners to come and invest in the sector, which has resulted in donor-funded activities for the formation of aquaculture parks and policy and identification of some farmer clusters. What remains is for businesses and groups such as WAFICOS to seize this opportunity and invest in the marketing infrastructure, train farmers, and provide technical information required for efficient running of enterprises.

The human capacity to support aquaculture development is limited, yet efforts in capacity building have been focused on fisheries in the past. While a degree in aquaculture has been introduced at Makerere University, the programme needs support to increase enrolment and sustain internship programmes. It also needs infrastructure to carry out research on species, feeds and seed to supplement NaFIRRI's efforts. These efforts would go a long way to promote development and commercialization of the subsector.

The future for aquaculture in general and tilapia farming in particular in Uganda is promising with all the ingredients present (e.g. water resources, right climate and high demand for fish). What is needed is to create the right environment and infrastructure for the private sector to thrive.

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ISBN 978-92-5-109756-4 ISSN 2070-6065



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I7258EN/1/05.17