
# Employment generation in the Egyptian aquaculture value chain

## Sustainable Transformation of Egypt's Aquaculture Market System (STREAMS) project

WorldFish

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**Research supported by**

# Contents

# Summary

Aquaculture is an important sector with high potential, not only to provide nutritious food but also to contribute to the national economy, and the aquaculture value chain provides substantial employment generation opportunities, including jobs for females and youths. The Sustainable Transformation of Egypt's Aquaculture Market System (STREAMS) project is being funded by the Swiss Agency for Development and Cooperation (SDC) for three years to support the Egyptian aquaculture sector. The project's mid-term review and steering committee, which requested an assessment about job creation in the aquaculture value chain to review the existing estimates, reported 14 full-time equivalent (FTE) jobs per 100 t of fish produced (Macfadyen et al. 2011). This study assesses employment generation along the main stages of the aquaculture value chain—namely hatcheries, feed mills, fish farms, and fish trade and retail. It also discusses the potential of job generation across the sector to contribute to the UN Sustainable Development Goals (SDGs). The study was conducted in April and May 2018 and included surveys in hatcheries (N=40), feed mills (N=14), fish farms (N=234), and fish trading and retailing (N=182) in the five governorates responsible for 80% of the national aquaculture output. We estimate that aquaculture generates 19.56 FTE jobs per 100 t of fish produced along the entire value chain. However, most of these are for males over 30 years old, with few jobs for females and younger people. Most jobs for females are currently generated at the retailing stage. Boosting employment generation across the entire value chain, especially for females and youths, could contribute to the attainment of multiple SDGs related to gender equality (SDG 5) and decent employment (SDG 8).


Workers in one of the hatcheries in Riyad village, Kafr El-Sheikh governorate, Lower Egypt.

# Introduction

## Aquaculture and employment

Global unemployment rates stand at an alarming 6%, with close to 200 million people out of work (World Bank 2017a). Unemployment rates in Africa are even higher, officially at 7.9% but possibly much higher (World Bank 2017a). For example, in some African countries, such as Egypt (12.1%), unemployment rates are even higher (World Bank 2017a).

Primary production sectors, such as agriculture, have been the backbone of the economies in several developing countries. For instance, agriculture is the highest single source of employment in Ghana, Nigeria, Mali and India, even though its actual contribution to the Gross Domestic Product (GDP) is lower (Olaniyi and Titilola 2014).

Aquaculture is an important economic sector with significant employment generation potential. Globally, it provides more than 23 million direct and indirect full-time jobs, largely concentrated in developing countries (Ottinger et al. 2016; Valderrama et al. 2010) the Aquaculture and Management Conservation Service (FIRA, and employment generation from aquaculture has been significant in regions that have struggled to develop more viable long-term employment options (Grealis et al. 2017). Furthermore, several studies have identified that exogenous interventions in aquaculture value chains can generate both employment and other co-benefits (Table 1). Women play a major role in aquaculture value chains globally (FAO 2016), but they often receive unequal benefits from their involvement (Kruijssen et al. 2018).

Global population growth and ongoing efforts to end world hunger can create significant employment generation opportunities in primary production sectors, and aquaculture is not an exception (FAO and OECD 2014). As a result of growth in population and per capita consumption, global fish demand is projected to increase by about 47 million metric tons in the next few years, with global aquaculture output increasing by 19 million (FAO 2017). The expected expansion could offer substantial employment generation opportunities, especially for females and youths, as well as possibilities for creating and expanding small- and large-scale businesses in the sector (FAO 2017; Shaalan et al. 2018). The huge demand-supply gap of more than 28 million metric tons (FAO 2017) creates even higher employment generation potential.

| Stage | Intervention | Employment generation | Co-benefits | Citation |
|---|---|---|---|---|
| Farm | • Technological intervention | 2,495 jobs created<br>• Fencing: 266 jobs<br>• Guarding: 580 jobs<br>• Harvesting: 1,648 jobs | • Increased income<br>• Food security | (Haque and Dey 2017) |
| Farm | • Knowledge<br>• Financing<br>• Marketing | Employment generation:<br>• 387 man-days (277 man-days) higher than the control | • Higher financial contribution to families compared to the control (INR 3,265/- vs. INR 2,490/-) | (Panda et al. 2012) |
| Farm | • Knowledge | • Employment generation from 6.3 to 9.7 human-days/household | • Increased income | (Mula and Sarker 2013) |
| Farm | • Mud crab farming<br>• Milkfish farming<br>• Mangrove nursery | • Increased employment | • Improved food supply<br>• Increased income<br>• Improved food security | (Mirera et al. 2014) |
| Farm | • Fish culture<br>• Fish-cum-duck culture<br>• Hatchery | • Increased employment | • Fish yield increases to 4–6 t/ha/yr (from a benchmark of about 1 t/ha/yr)<br>• Reduced vulnerability<br>• Wealth generation | (Chakrabarti et al. 2017) |
| Farm<br>Hatchery<br>Other stages | • Bangladesh country-level data | • Employment generation<br>• 3.15 million FTE jobs (at farm level)<br>• 642,000 FTE jobs (at other stages) | • Reduced vulnerability<br>• Reduced poverty<br>• Improved food security | (Phillips et al. 2016) |

**Table 1**. Employment generation and other co-benefits from aquaculture interventions.

## Key aspects of the Egyptian aquaculture sector

Egypt is one of the countries where aquaculture can generate important socioeconomic benefits, with total fish production capacity estimated at over 1.7 million metric tons. In 2016, fish production contributed about USD 3.6 billion to Egypt's GDP, and aquaculture had a substantial contribution as it provides more than 80% of total fish production (GAFRD 2018). This makes Egypt Africa's largest aquaculture producer (FAO 2018; Shaalan et al. 2018).

Aquaculture employs over 580,000 people (Shaalan et al., 2018), but this figure might be an overestimate (FAO 2018). Apart from direct permanent jobs, other employment opportunities include seasonal workers during harvesting and other periods of intensive activity, as well as indirect employment in the fish trade, transport, processing, retailing, and boat and net manufacturing sectors (FAO 2009).

Current growth and especially the potential of future expansion suggest that aquaculture can contribute to curbing Egypt's persistently high unemployment rates, particularly for women and youths. At the same time, aquaculture can have other multiple benefits for a country that faces various interlinked challenges (Box 1).

**Box 1. Major socioeconomic challenges in Egypt.**

Egypt faces a series of interlinked challenges related to increasing population, urbanization and unsustainable consumption and production patterns (Galli et al. 2017; Osama et al. 2017). The current population is close to 100 million and is projected to increase to over 150 million by 2050. Approximately 60% of the population is under the age of 30, and an estimated 20% live on less than USD 1 per day (World Bank 2017b).

While unemployment rates have been declining in recent years, the current unemployment rate of 12.1% is quite high compared to global standards (6%) (Section 1.1). Youth unemployment is high both for males (29% in 2016) and females (45% in 2016) (World Bank 2016), while women make up only 24% of the labor force (World Bank 2015).

Egypt ranks 135th out of 144 countries for gender equality in economic participation and opportunity (World Economic Forum 2017). Such strong gender disparities are a result of various factors, such as social norms and attitudes, economic pressures, religious beliefs, access to finance and markets, and structural forces (Assaad and Krafft 2013; Biltagy 2014; Nassar and Biltagy 2017).

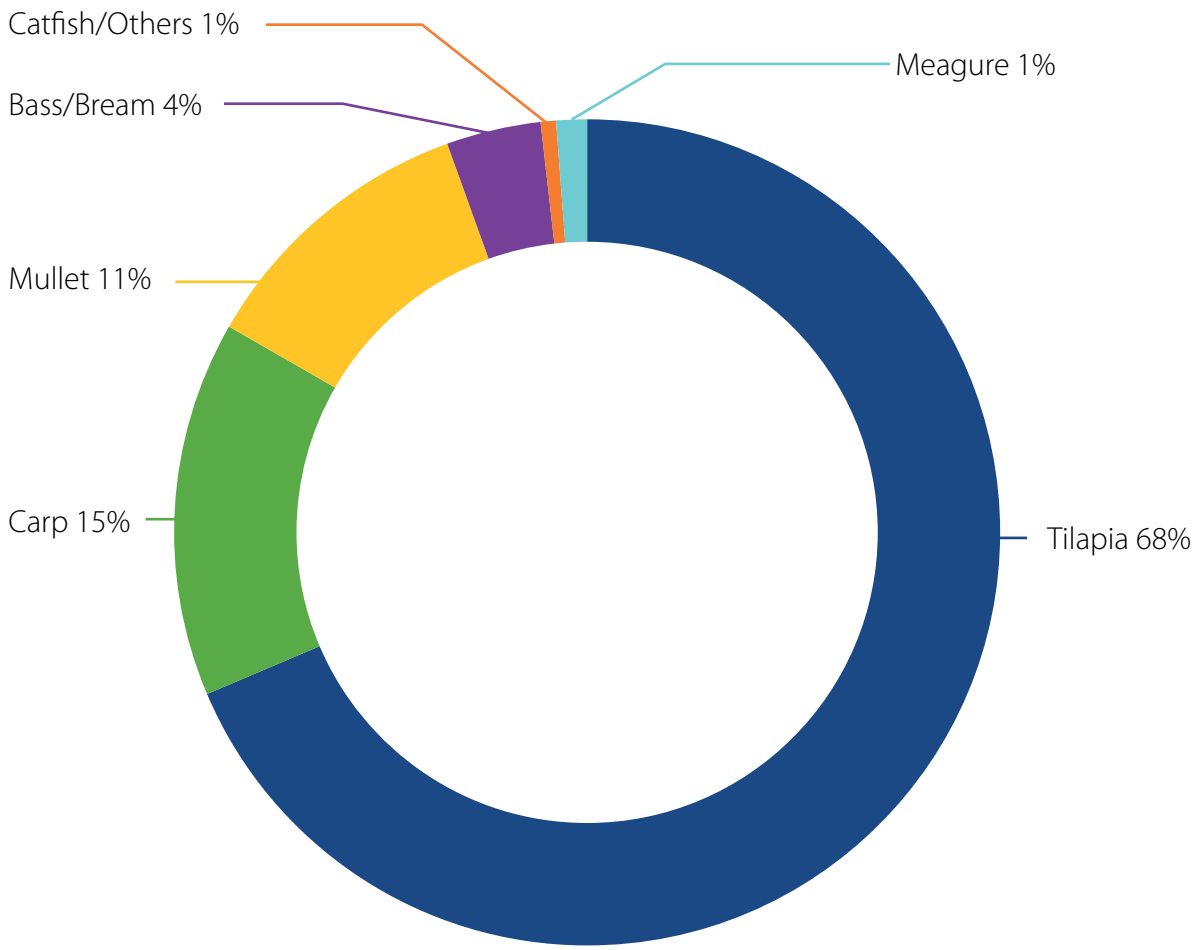
Per capita consumption of local fish increased by 75% between 2007 and 2016, from 13.5 kg/year to over 18 kg/year. Currently, fish provides approximately 38% of the animal protein demand for Egypt's population (CAPMAS 2018) and is an affordable source of micronutrients that are essential for good health. The increase in per capita fish consumption is currently higher than for beef and poultry, which further highlights the growing importance of fish in local diets.

At the same time, total fish production capacity has been increasing substantially (Table 2). Aquaculture currently provides almost 69% of Egypt's fish needs. The overall share of aquaculture in domestic fish production grew from 47% in 2000 to 80% in 2016 (Table 2). This is mainly attributed to the extensive promotion and adoption of new technologies, such as the use of extruded feed and improved farm management practices (Hebisha and Fethi 2014).

In terms of produced species, tilapia dominates, accounting for more than two-thirds of all fish produced through aquaculture in 2016 (Figure 1). Other important species, or species groups, include carp (Cyprinids, mainly common carp and silver carp, 15%), mullet (*Mugilidae* spp., 11%) and catfish (*Clarias* spp., 2.5%). Egypt is the third-largest tilapia producer in aquaculture globally (after China and Indonesia) and the largest producer of mullet (GAFRD 2018).

The positive effects of aquaculture for the national economy have triggered both governmental agencies and nongovernmental organizations to implement different interventions in the sector (Shaalan et al. 2018). Major projects implemented by the government of Egypt include the National Project for Marine Aquaculture in

the Suez Canal and the Gilion Lake Project in Kafr El Sheikh (Wally 2016). These projects, among others, have contributed to the rapid expansion in support activities such as local feed mills and hatcheries, which has further made the sector more sophisticated and diverse.




*Source: GAFRD 2018.*

**Figure 1**. Fish species produced through aquaculture in 2016.

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Fisheries production (1,000 t) | 372 | 374 | 387 | 385 | 375 | 354 | 357 | 345 | 344 | 336 |
| Aquaculture production (1,000 t) | 636 | 694 | 705 | 922 | 987 | 1,018 | 1,098 | 1,137 | 1,175 | 1,371 |
| Total fisheries production (1,000 t) | 1,008 | 1,068 | 1,093 | 1,307 | 1,362 | 1,372 | 1,454 | 1,482 | 1,519 | 1,706 |
| Fish farming production (% of total) | 62.9 | 64.8 | 64.4 | 70.3 | 72.4 | 74.2 | 75.5 | 76.7 | 77.3 | 80.3 |
| Fish imports (1,000 t) | 258.9 | 136.8 | 135.5 | 256.8 | 182.2 | 335 | 236 | 354.6 | 296.1 | 311.1 |
| Fish exports (1,000 t) | 4.4 | 6.7 | 7.6 | 10.6 | 9.5 | 16 | 20 | 28.0 | 19.7 | 47.8 |
| Fish farming as % of total consumption (%) | 50.2 | 57.8 | 57.6 | 59.2 | 64.2 | 60.0 | 65.7 | 62.9 | 65.4 | 69.6 |
| Local fish supply (kg/yr) | 13.50 | 14.13 | 14.13 | 16.44 | 16.82 | 16.48 | 16.94 | 16.75 | 16.85 | 18.22 |
| Local and imported fish supply (g/yr) | 16.98 | 15.95 | 15.89 | 19.7 | 19.09 | 20.55 | 19.73 | 23.47 | 20.83 | 21.64 |

*Source: GAFRD 2018.*

**Table 2**. Key statistics for fisheries and aquaculture in Egypt.

# Intervention and aim of study

Considering the interlinked challenges outlined in Section 1.2, WorldFish helped to implement STREAMS in 2015 with funding from the Swiss Development Cooperation (SDC) and in collaboration with CARE Egypt. The project aims at making a positive impact on fish farmer and trader communities in Egypt through (a) introduction of improved tilapia strains with greater yields, (b) training of small-scale aquaculture businesses in best management practices, and (c) improved conditions for female fish retailers. This investment targets key areas of aquaculture production and retailing with the aim of boosting employment, especially for women.

STREAMS also provides support for existing and prospective fish farmers in the main fish farming governorates (Kafr El Sheikh, Behera, Fayoum Sharkia) and El-Mineya in Upper Egypt. The project facilitated the establishment of an aquaculture innovation platform. Furthermore, the main aquaculture fish producer organizations (in Fayoum, Kafr el Sheikh, Sharkia, Behera and El-Mineya) are provided with capacity-building support.

According to the theory of change for the CGIAR Research Program (CRP) on Fish Agri-Food Systems (FISH) (Figure 2), these interventions are expected to alleviate poverty through increased fish productivity as well as income and employment generation throughout the aquaculture value chain. However, a first step in evaluating the effectiveness of STREAMS is to understand employment generation patterns in the overall aquaculture sector. The current benchmark is the study by Macfadyen et al. (2011), which quantified employment creation along the aquaculture value chain at 14 FTE jobs per 100 t increase in fish production.


Tilapia seeds in one of Riyad village hatcheries, Kafr El-Sheikh, Lower Egypt.

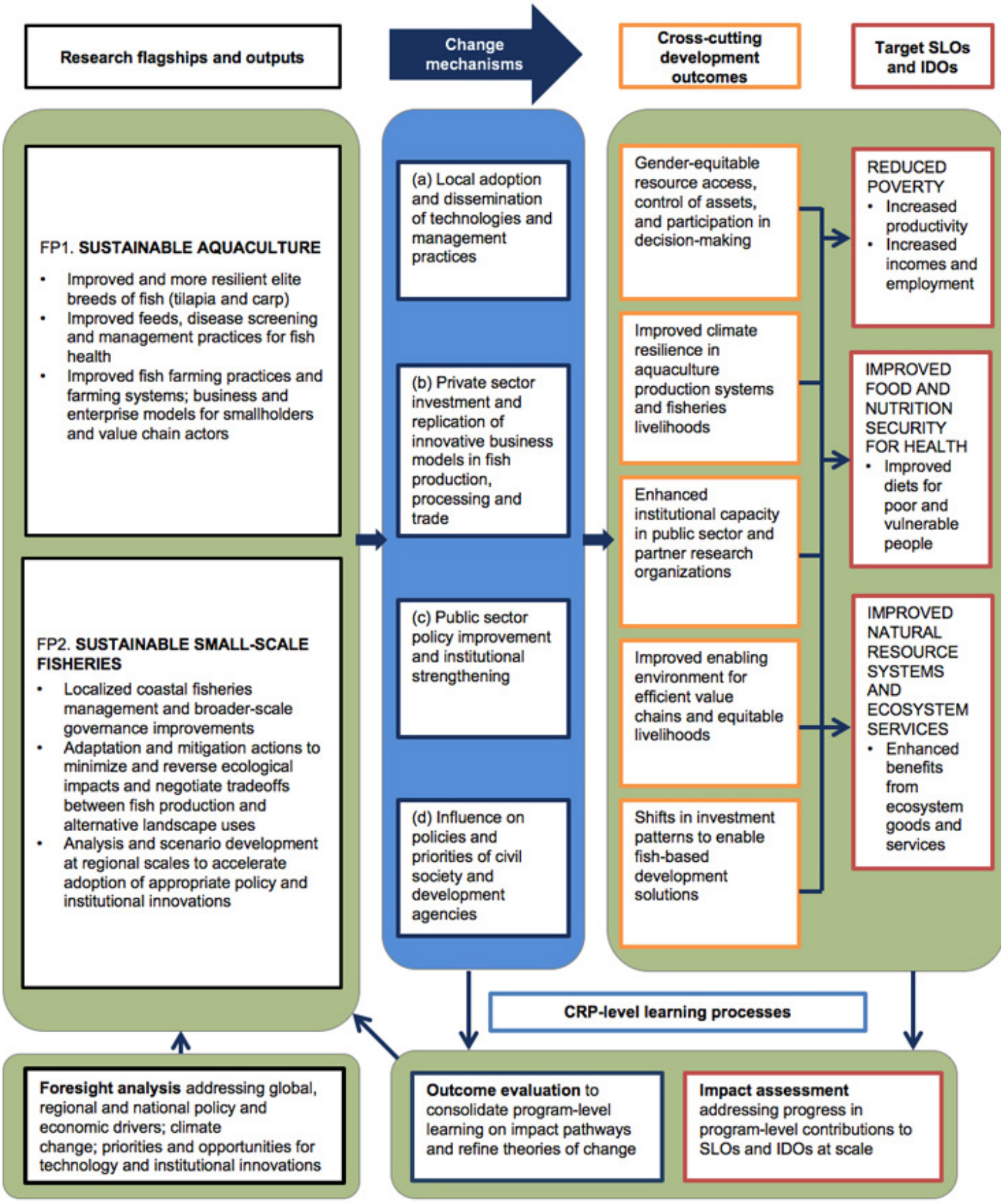
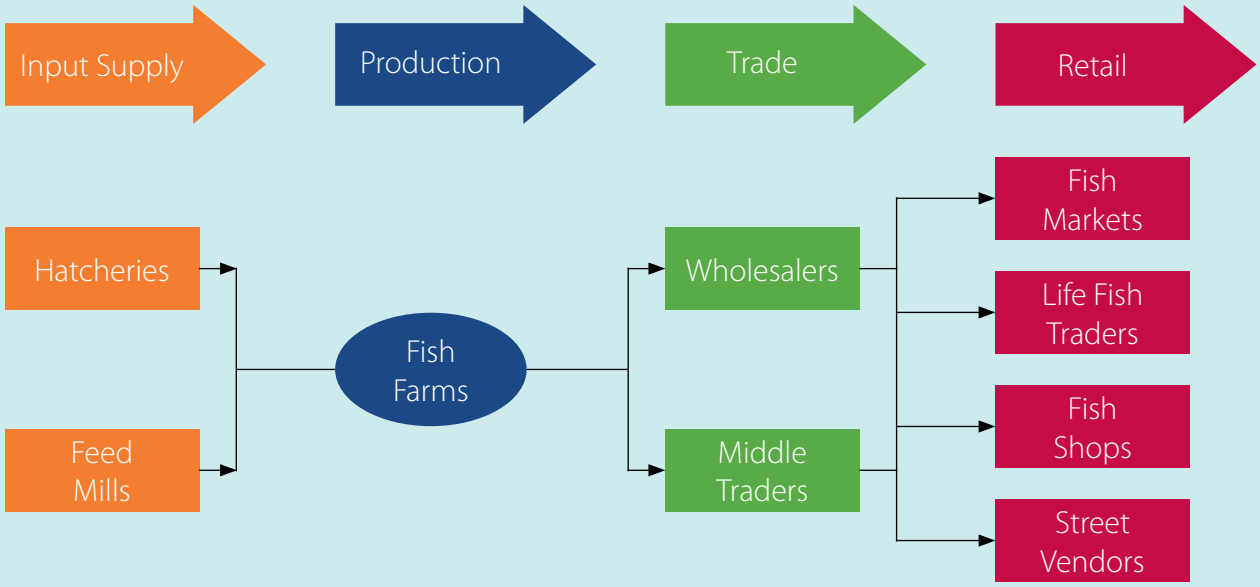



**Figure 2**. CRP-level impact pathways and theory of change overview.

Thus the aim of this study is to assess employment generation across the aquaculture value chain in Egypt and compare it with existing estimates (Box 2). We focus on areas that have received intervention from STREAMS. In particular, we surveyed feed mills, hatcheries, fish farms and traders/retailers in the governorates of Behera, Fayoum, Kafr El-Sheikh and Sharkia. Collectively these governorates provided more than 80% of the freshwater fish produced in Egypt in 2016 (GAFRD 2018). We also sampled fish farms in the governorate of Dammietta to assess job creation in farms that produce marine fish. This report quantifies employment generation across the Egyptian aquaculture value chain to test this assumption and inform the STREAMS steering committee regarding project decisions and areas of further assistance.

**Box 2. Egyptian aquaculture chain.**

The value chain comprises feed mills, hatcheries, fish farms and traders/retailers (Figure 3). These stages reflect radically different roles within the value chain.




*Source: modified from Macfadyen et al. 2011 and Macfadyen et al. 2012b.*

**Figure 3**. Aquaculture value chain in Egypt and linkages among the main actors.

There are 440 hatcheries (Nasr-Allah et al. 2014) and 60 feed mills (El-Sayed 2014) in Egypt. Hatcheries typically produce all male tilapia fry and fingerlings, which are then mostly sold to fish farms. On average, hatcheries are 1.7 ha large and have about 10,700 of brooders per hatchery (Nasr-Allah et al. 2014). Feed mills produce extruded and pelletized fish feed, mainly for tilapia, at a protein level that ranges between 25% and 45% (El-Sayed 2014).

Almost all aquaculture output comes from small- and medium-sized privately owned fish farms. Freshwater fish farms produce the bulk of fresh fish in the country, mainly using earth ponds (responsible for 86% of total production in 2016) and cages (12.8%) (GAFRD 2018).

Fish farms distribute fish to traders and wholesalers, and these larger traders distribute fish to retailers and food service outlets (e.g. restaurants) usually within 1 day of purchase. On average, these traders sell 99% of the fish bought, amounting to an average sales volume of 1112 t per year worth EGP 11.9 million (Macfadyen et al. 2012b). Retailers sell live or fresh fish (with or without ice) directly to domestic consumers and are typically in possession of the fish for 1 day. On average, retailers have a sales volume of 65 t worth EGP 940,000 (Macfadyen et al. 2012b) while fish retailers trading Lake Nasser fish sell 34 t worth EGP 438,573 per year (Nasr-Allah et al. 2016).

# Methodology

## Questionnaire design and survey preparation

Data was collected through questionnaires that targeted different groups within the aquaculture value chain—namely hatcheries, feed mills, fish farms and the postharvest subsector, including traders, wholesalers and retailers (Figure 3). We drafted a different questionnaire for each group to reflect its different operations and roles within the value chain. All four versions included questions about the output and the employment profiles (e.g. number of permanent/temporary employees, employment type for each gender) of the operations. The questionnaires were drafted in English and then translated into Arabic.

Three questionnaires were piloted at WorldFish Abbassa: one at a hatchery, one at a fish farm and one with a fish trader/retailer. Following the piloting, we revised the draft surveys, integrating the lessons learned and then trained the enumerators that undertook the data collection. Contacts were made ahead of the field visits in each governorate to facilitate community entry.

## Sampling design

Our study focused on the governorates of Behera, Fayoum, Kafr El-Sheikh and Sharkiam, which collectively accounted for more than 80% of freshwater fish produced in Egypt in 2016 (GAFRD 2018). We also sampled fish farms in the governorate of Dammietta to assess job creation on farms that produce marine fish. In total, we aimed to interview 40 hatcheries, 15 feed mills, 200 fish farms and 184 fish traders (Tables 3–4). However, given the different type of information available to the research team we had to slightly modify the surveyed numbers (Table 3–4) and resort to different sampling procedures to ensure the effective randomization of the samples.

We sampled hatcheries and feed mills through a database provided by WorldFish contacts in the different governorates. From this database we randomly selected the feed mills and hatcheries to be interviewed in each governorate.

As there is no comprehensive database of fish farms in Egypt, we adopted a stratified random sampling approach. First, we identified the number of fish farms to be surveyed in each governorate, based on the fish production output of each governorate compared to total national fish production. This proportionate sampling approach was used to avoid oversampling fish farms from any given governorate. Once we decided the number of fish farms to be sampled in each governorate, we used local WorldFish contacts to arrange farmer visits in different villages in every governorate. In each village, we selected fish farms randomly through transect walks. Starting from a fixed point, enumerators walked in each direction,

| | Wholesalers | Middle traders | Retailer | | | Live fish sale |
|---|---|---|---|---|---|---|
| | | | Fish shops | Fish markets | Street vendors | |
| Behera | 4 (4) | 4 (4) | 7 (7) | 7 (7) | 7 (7) | 4 (4) |
| Fayoum | 4 (4) | 4 (4) | 6 (6) | 6 (6) | 6 (6) | 4 (4) |
| Kafr El-Sheikh | 10 (9) | 10 (10) | 20 (21) | 20 (21) | 20 (20) | 8 (7) |
| Sharkia | 4 (8) | 4 (0) | 7 (7) | 7 (7) | 7 (6) | 4 (5) |
| Total | 22 (25) | 22 (18) | 40 (41) | 40 (41) | 40 (39) | 20 (20) |

**Table 3**. Number of planned and implemented interviews (in parenthesis) by governorate and value chain actor.

| | Wholesalers | Middle traders | Retailer | | | Live fish sale |
|---|---|---|---|---|---|---|
| | | | Fish shops | Fish markets | Street vendors | |
| Behera | 4 (4) | 4 (4) | 7 (7) | 7 (7) | 7 (7) | 4 (4) |
| Fayoum | 4 (4) | 4 (4) | 6 (6) | 6 (6) | 6 (6) | 4 (4) |
| Kafr El-Sheikh | 10 (9) | 10 (10) | 20 (21) | 20 (21) | 20 (20) | 8 (7) |
| Sharkia | 4 (8) | 4 (0) | 7 (7) | 7 (7) | 7 (6) | 4 (5) |
| Total | 22 (25) | 22 (18) | 40 (41) | 40 (41) | 40 (39) | 20 (20) |

**Table 4**. Number of planned and implemented interviews (in parenthesis) by governorate for fish traders.

visiting the first farm on right hand side followed by the third farm on the left hand side and then again the third farm on the right hand side. This transect walk approach allowed for a high degree of randomization.

Fish traders were selected through snowballing sampling. At the beginning of the survey, the enumerators visited the wholesale fish market in the capital city of each governorate. Through this initial visit, we developed a list of wholesalers, middle traders and other retailers. The wholesalers who were interviewed identified traders in other districts within the governorate. After finishing the interviews in the capital of each governorate, the enumerators moved to different districts until the desired sample was achieved. Through this process, the following 11 districts were visited in four governates:

- Kafr El-Sheikh governorate: Kafr El-Sheikh, Desouk, El-Hamoul and Balteem districts
- Beheira governorate: Rashid, Badr and Edko districts
- Fayoum governorate: Fayoum and Ibshwai districts
- Sharkia governorate: Belbies and Abou Hamad districts.

## Data treatment and analysis

Data from the hard-copy questionnaires was entered into Excel spreadsheets and checked for validity and correctness by the enumerators responsible for completing the individual interviews. The data was then analyzed through descriptive statistics to generate information about business volume and employment generation across the value chain.

To calculate the employment generation, we converted part-time jobs to FTEs and aggregated them with the full-time jobs. We calculated overarching employment generation indices as follows:

- Hatcheries: FTE jobs generated per 660,000 tilapia seed, which is necessary for producing 100 t of fish (FTE per 100 t of fish). This is based on the survival rate 57.2% for tilapia fry to market size in growing ponds (Bolivar et al., 2004), and an average tilapia harvest weight of 265g (Macfadyen et al., 2012b)490tonnes in 2009 (Section 4.2).
- Feed mills: FTE jobs generated per 150 t of produced fish feed, which is necessary for producing 100 t of fish (FTE per 100 t of fish). Calculated at FCR 1.5 as reported (Dickson et al., 2016) (Section 4.3).
- Fish farms: FTE jobs generated per 100 t of produced fish (FTE per 100 t of fish) (Section 4.4)
- Traders/retailers: FTE jobs generated per 100 t of sold fish (FTE per 100 t of fish) (Section 4.5).

To assess better whether job creation varied between age groups, we also calculated the FTE for those above 30 years of age (FTE>30/100 t) and below (FTE<30/100 t). We also calculated the FTE for women across the chain.

In addition, we calculated employment generation for ancillary transport services at each stage of the value chain. However, because of the nature of transport activities and the fact that service providers change from time to time, it is not possible to accurately calculate employment generation by gender and age. For this reason, we calculated only the overall transport-related employment generation (in FTE jobs per 100 t of fish produced), not differentiating by age group and gender.

Finally, we aggregated the estimated values for each stage of the value chain to derive the employment generation for the entire value chain (Section 4.6).

## Design consideration and data quality assurance

The survey for the entire aquaculture value chain entailed some difficulties as the sector extended over a wide geographical area and included many different actors. In particular, the information initially available to the research team was not consistent among the different stages of the value chain. Contrary to hatcheries and feed mills, there is no comprehensive database of fish farms and fish traders/retailers operating in the different governorates, so we could not randomly select fish farms and fish traders/retailers from lists, as we did for hatcheries and feed mills. To ensure the effective randomization of the sample, fish farmers were selected though transect walks, and fish traders/retailers through snowballing. Although the randomization process has been robust, there should be caution when comparing the levels of employment generation between the different stages of the value chain.

Furthermore, it is difficult to accurately estimate employment generation for transport-related activities. It is particularly problematic to provide disaggregated information by age and gender, as transport services are often outsourced and the transport service vendors can change over time (even within the same year). The respondents were unable to report accurately the age and gender of the actual transport service providers, so we opted to report aggregate employment generation estimates not differentiating by gender and age. While it is highly possible that males will dominate the employment profile of transport services, it is not possible to infer employment generation by age with a high degree of accuracy.

Our survey did not attempt to elicit information about skill level, wages, job quality and satisfaction with employment. To elicit such variables with a high degree of accuracy, it is necessary to interview every single employee, which was not logistically possible under the focus and constraints of the current report. This is an important aspect that will be addressed in the final impact assessment study at the end of project.

We are certain that despite the variability in the sampling approaches between groups and the short surveys to facilitate recollection, the obtained data and results are quite robust. They reflect well the actual differences in individual financial performance. To enhance data quality, the following specific steps were taken:

- An iterative survey design was followed, where the initial survey was developed through extensive work and prior knowledge of the context and was refined through piloting.
- Enumerators were trained thoroughly.
- Reliable WorldFish contacts were used to access fish farms in the study sites.
- Data collection team members with previous data collection experience were selected.
- Specialist aquaculture sector knowledge and previous experience of all members of the design and field team were mobilized.

The international technical expert team prepared an initial draft of this report, which was then circulated to all team members for their comments. Based on feedback, revisions were made before finalization.


A women fish retailer selling and cleaning live fish on a street corner in Fayoum.

## Characteristics of the value chain

On average, each hatchery produced 8 million seed. The highest average seed production per hatchery is in Sharkia (10.5 million) followed by Behera (8 million) and Kafr El Sheikh (7.6 million) (Annex 1, Table S1). Seed comes overwhelmingly in the form of fry (93%) rather than fingerlings (7%). The average hatchery size is 1.33 ha, with hatcheries in Sharkia being on average the largest (1.64 ha). However, hatcheries in Kafr El Sheikh have the highest seed production per unit area (9.45 million seed per ha), which makes them more intensive and high yielding compared to hatcheries in Behera and Sharkia.

The average production capacity of feed mills varies, at 8500 t/yr in Behera, 12,167 t/yr in Kafr El-Sheikh and 2667 t/yr in Sharkia. Feed mills in Behera and Sharkia produce only pelleted feed, while mills in Kafr El-Sheikh produce both pelleted (29%) and extruded feed (71%) (Annex 1, Table S2). Most of the surveyed feed mills normally run a single work shift, but some in Kafr El-Sheikh run two or three. This is reflected in their higher (on average) production capacity.

Average fish production per fish farm was 93.5 t (63.9–144.5 t) or 10.3 t/ha (9.4–12.2 t/ha) (Annex 1, Table S3). Figure 4 outlines fish productivity per unit area for different species, highlighting the much higher productivity of tilapia per unit area.

On average, respondents in trading and retailing have been operating for 9.8 years. Respondents in the governorate of Fayoum have the highest average experience (16 years), followed respondents in Behera (9.3), Sharkia (8.4) and Kafr El-Sheikh (8.4). From a gender perspective, 72% of respondents in trading and retailing are male and 28% female, with male respondents dominating all governorates, apart from Fayoum (Table 5). Sales volume varied substantially between the different types of fish traders and retailers (Table 5).

## Employment generation in hatcheries

On average, hatchery-related job creation across the study governorates amounts to 3.76 FTE jobs per hatchery and 0.41 FTE jobs per 660,000 fry (equivalent to 100 t of fish produced), including contribution from ancillary transport services (Table 6). In particular, hatcheries in the governorate of Behera generate the most jobs (0.54 FTE jobs per 660,000 fry and 5.21 FTE jobs per hatchery), followed by hatcheries in Sharkia (0.27 FTE jobs per 660,000 fry and 4.01 FTE jobs per hatchery) and Kafr El-Sheikh (0.41 FTE jobs per 660,000 fry and 3.46 FTE jobs per hatchery).

There is almost equal employment generation across age groups in terms of FTE jobs per hatchery, with hatcheries in Behera and Sharkia generating on average more jobs for people below 30 years of age for both major employment indicators (Table 6, Figure 5). We did not identify any employment generation for females in any governorate.

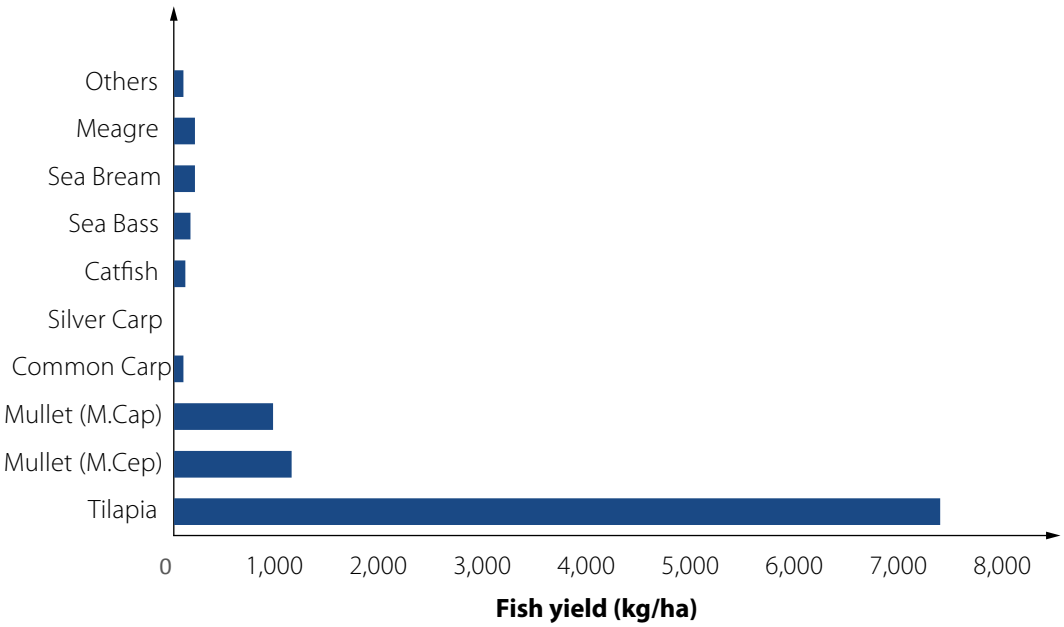



**Figure 4.** Average pond productivity per unit area for different fish species.

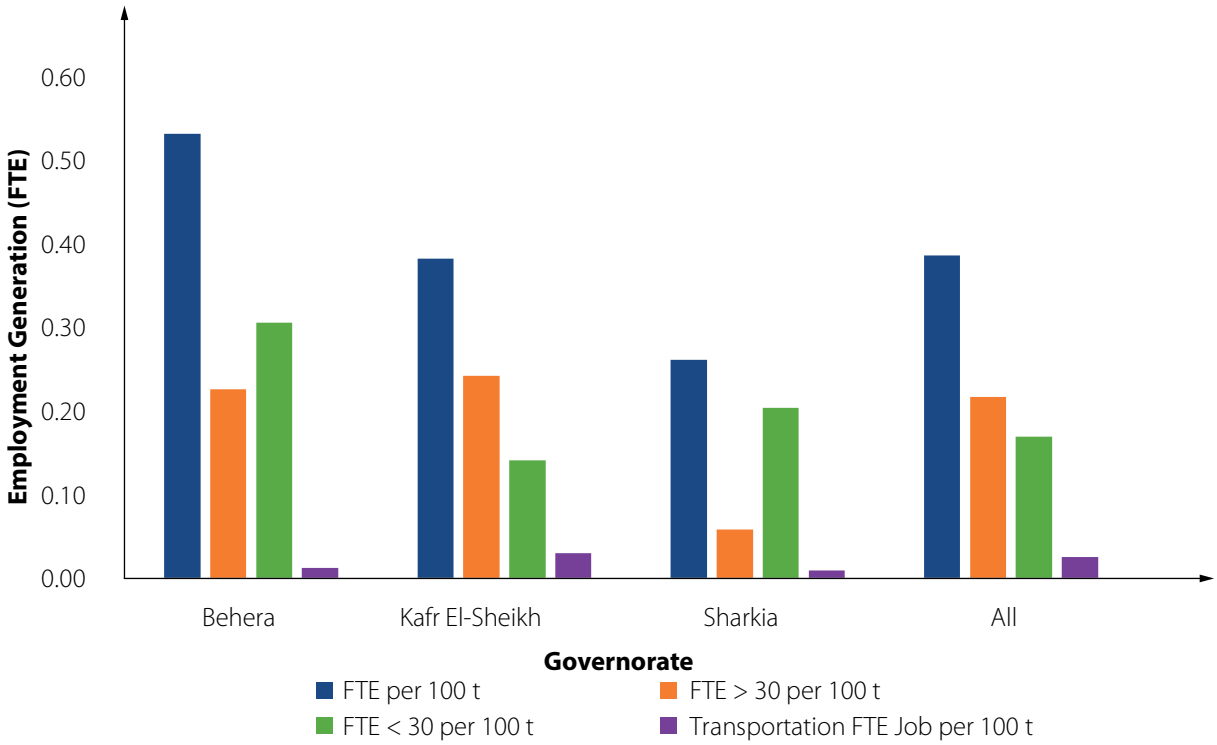



**Figure 5**. Hatcheries' FTE jobs generation per 660,000 fry (equivalent to 100 t fish).

| | Behera | Fayoum | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|---|
| **Gender (%)** | | | | | |
| Male | 85 | 60 | 72 | 73 | 72 |
| Female | 15 | 40 | 28 | 27 | 28 |
| Average family size | 4.5 | 5.2 | 5.3 | 4.2 | 4.9 |
| Period of operation (years) | 9.3 | 16.0 | 8.4 | 8.5 | 9.8 |
| **Sales volume (t/yr)** | | | | | |
| Middle traders | 5,355 | 468 | 459 | - | 1,549 |
| Wholesalers | 1,275 | 400 | 442 | 901 | 715 |
| Fish shops | 50 | 26 | 70 | 20 | 52 |
| Fish markets | 16 | 16 | 56 | 21 | 37.3 |
| Street vendors | 12 | 13 | 30 | 20 | 22.6 |
| Live fish traders/transporters | 9 | 18 | 32 | 16 | 22.2 |

**Table 5**. Socioeconomic information of fish traders and sales volume.

| | Behera | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|
| FTE jobs per hatchery | 5.08 | 3.23 | 3.90 | 3.55 |
| FTE jobs >30 per hatchery | 1.94 | 1.92 | 0.70 | 1.77 |
| FTE jobs <30 per hatchery | 3.14 | 1.31 | 3.20 | 1.78 |
| Transportation FTE jobs per hatchery | 0.13 | 0.23 | 0.11 | 0.21 |
| FTE jobs per hatchery incl. transport | 5.21 | 3.46 | 4.01 | 3.76 |
| FTE jobs per 660,000 fry (or 100t fish) | 0.53 | 0.38 | 0.26 | 0.39 |
| FTE jobs >30 per 660,000 fry (or 100 t fish) | 0.23 | 0.24 | 0.06 | 0.22 |
| FTE jobs <30 per 660,000 fry (or 100 t fish) | 0.31 | 0.14 | 0.20 | 0.17 |
| Transportation FTE jobs per 660,000 fry (or 100 t fish) | 0.01 | 0.03 | 0.01 | 0.02 |
| FTE jobs per 660,000 fry (or 100 t fish) incl. transport | 0.54 | 0.41 | 0.27 | 0.41 |

**Table 6**. Employment generation indicators for hatcheries.

## Employment generation in feed mills

On average, feed mill-related job creation amounted to 3.85 FTE jobs per feed mill or 0.39 FTE jobs per 150 t of feed produced (equivalent to 100 t of fish produced), including from ancillary transport services (Table 7). Overall job creation ranged from 0.74 FTE jobs per 150 t of feed in Sharkia, to 0.35 in Behera and 0.29 in Kafr El-Sheikh, all including employment contribution from transportation (Table 7).

Employment generation is relatively well balanced between employees under 30 years of age (0.12 FTE jobs <30 per 150 t of feed) and over 30 years old (0.18 FTE jobs >30 per 150 t of feed). Employment generation in feed mills in Sharkia is almost the same between age groups, while in Behera job generation is higher for those below 30 years (Table 7; Figure 6). As in the hatcheries, only males occupy jobs in feed mills.

## Employment generation in fish farms

On average, fish farm-related jobs amounted to 7.03 FTE jobs per 100 t of fish produced, including from ancillary transport services. The overall job generation ranges (FTE jobs per 100 t) between governorates are as follows: Fayoum (7.85), Behera (7.34), Kafr El-Sheikh (6.74), Damietta (6.76) and Sharkia (5.63), all including employment generation from ancillary transport services (Table 8). There is no job generation for females in the surveyed fish farms.

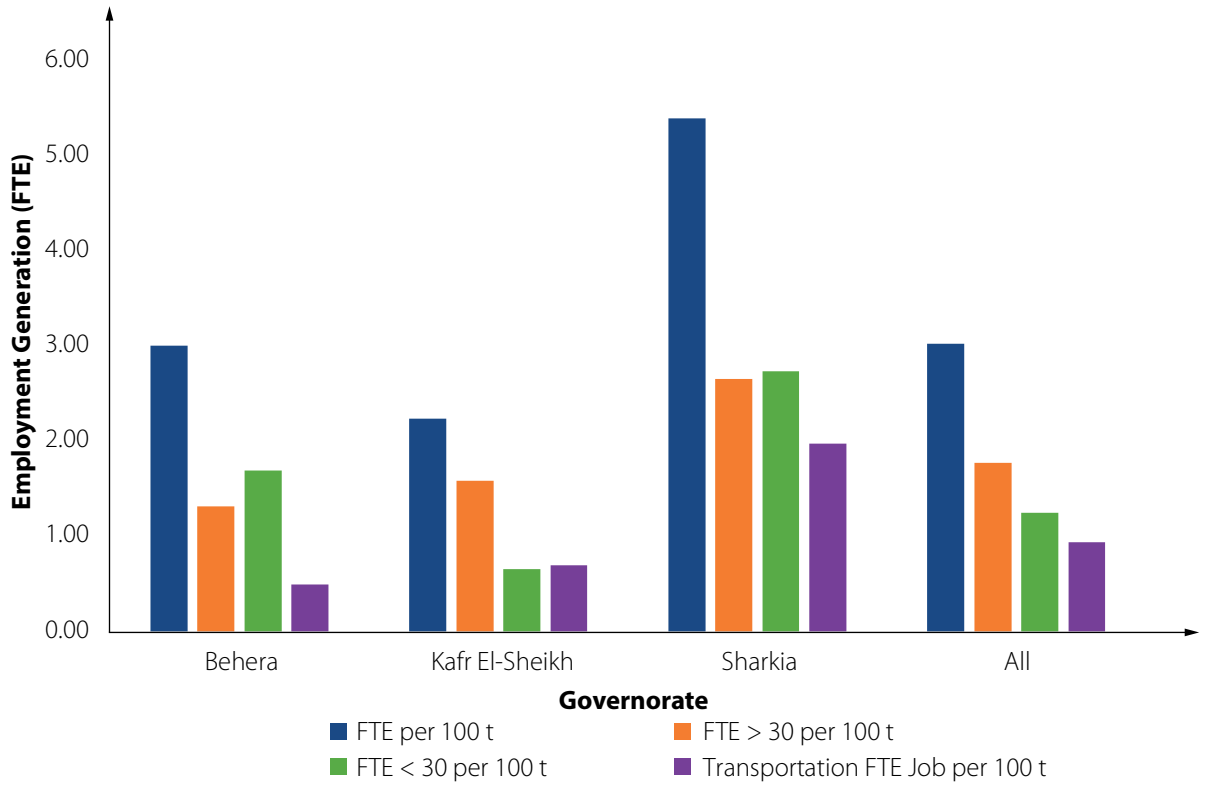



**Figure 6**. Feed mills' FTE jobs generation per 150 t of feed (equivalent to 100 t of fish).

| | Behera | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|
| FTE jobs per feed mill | 18.40 | 14.82 | 7.72 | 13.81 |
| FTE jobs >30 per feed mill | 7.00 | 10.21 | 3.82 | 8.38 |
| FTE jobs <30 per feed mill | 11.40 | 4.62 | 3.90 | 5.43 |
| Transportation FTE jobs per feed mill | 2.73 | 4.32 | 3.18 | 3.85 |
| FTE jobs per feed mill incl. transportation | 21.13 | 19.14 | 10.90 | 17.66 |
| FTE jobs per 150 t feed (or 100 t of fish) | 0.30 | 0.22 | 0.54 | 0.30 |
| FTE jobs >30 per 150t feed (or 100 t of fish) | 0.13 | 0.16 | 0.27 | 0.18 |
| FTE jobs <30 per 150t feed (or 100 t of fish) | 0.17 | 0.07 | 0.27 | 0.12 |
| Transportation FTE jobs per 150 t feed (or 100 t of fish) | 0.05 | 0.07 | 0.20 | 0.09 |
| FTE jobs per 150 t (or 100 t of fish) incl. transportation | 0.35 | 0.29 | 0.74 | 0.39 |

**Table 7**. Employment generation indicators for feed mills.

On average, twice as many jobs are generated for individuals above 30 years of age (4.21 FTE jobs >30 per 100 t, compared to 2.11 FTE jobs <30 per 100 t). This substantially higher job generation for older people is evident across all five study governorates. In some extreme cases, job generation (FTE jobs >30 per 100 t) is three times lower for younger people than for older people: e.g. Fayoum (5.03 vs. 1.75) and Damietta (4.44 vs. 1.49) (Table 8; Figure 7).

## Employment generation is fish marketing

The overall number of FTE jobs created per 100 t of sales volume varied among different players, but is much lower for middle traders and wholesalers (Table 9) than retailers (Table 10). In particular, when taking into account transportation, job generation is 1.59 FTE jobs per 100 t of fish sold for wholesalers and middle traders (Table 9). Disaggregated data estimates employment generation of 1.63 FTE jobs per 100 t for middle traders and 1.56 for wholesalers. Most jobs are created for males over 30 years old, with very limited job generation for females (only observed for wholesalers in Fayoum) (Table 9).

More substantial job generation is observed in fish retailing across all governorates (Table 10). In particular, when taking into consideration job generation from ancillary transport services, job creation amounts to 10.13 FTE jobs per 100 t of sold fish. Disaggregated data suggests that generation of FTE jobs per 100 t was 11.87 for fish shop retailers, 7.38 for fish market retailers, 9.79 for street vendors and 13.59 for live fish sellers and transporters. In contrast to other stages of the value chain, retailing offers substantial employment opportunities for females and youths. Street vending and live fish sales/transport are the only stages of the value chain with parity between the jobs generated for males and females (Figure 8).

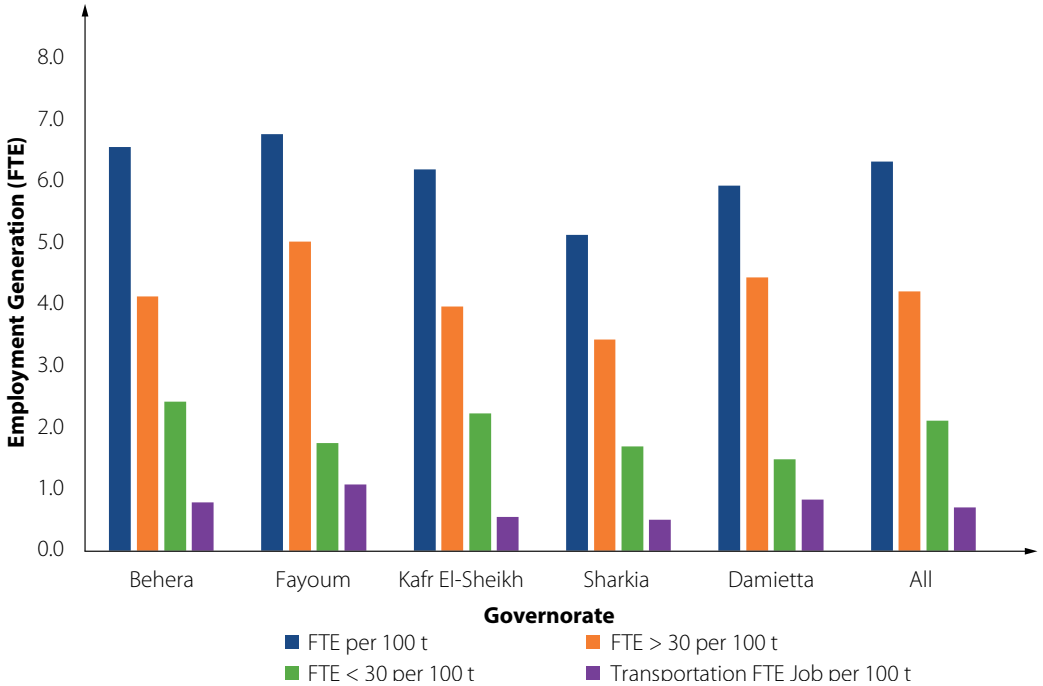



**Figure 7**. Fish farms' FTE job generation per 100 t of fish

| | Behera | Fayoum | Kafr El-Sheikh | Sharkia | Damietta | Average |
|---|---|---|---|---|---|---|
| FTE jobs per farm | 6.03 | 3.23 | 3.08 | 5.89 | 6.90 | 5.91 |
| FTE jobs >30 per farm | 3.80 | 2.40 | 1.97 | 3.94 | 5.17 | 3.94 |
| FTE jobs <30 per farm | 2.23 | 0.83 | 1.11 | 1.95 | 1.73 | 1.98 |
| Transportation FTE jobs per farm | 0.61 | 0.54 | 0.21 | 0.66 | 0.90 | 0.45 |
| FTE jobs per farm incl. transportation | 6.64 | 3.77 | 3.29 | 6.55 | 7.80 | 6.36 |
| FTE jobs per 100t fish | 6.56 | 6.77 | 6.19 | 5.13 | 5.93 | 6.32 |
| FTE jobs >30 per 100 t of fish | 4.13 | 5.03 | 3.97 | 3.43 | 4.44 | 4.24 |
| FTE jobs <30 per 100 t of fish | 2.42 | 1.75 | 2.23 | 1.70 | 1.49 | 2.08 |
| Transportation FTE jobs per 100 t of fish | 0.78 | 1.08 | 0.55 | 0.50 | 0.83 | 0.71 |
| FTE jobs per 100 t of fish incl. transportation | 7.34 | 7.85 | 6.74 | 5.63 | 6.76 | 7.03 |

**Table 8**. Employment generation indicators for fish farms.

## Employment generation across the value chain

The value chain analysis indicates the creation of about 19.1 FTE jobs per 100 t of fish produced, including employment generation from ancillary transport services (Table 11). The trading and retailing segment of the value chain generated the highest number of jobs at an average of 8.96 FTE jobs per 100 t of fish produced, with an added 2.29 FTE jobs per 100 t of fish produced from ancillary transport activities (Table 11). In the trading and retailing stages, the generated jobs were overwhelmingly permanent (96% and 99% respectively) (Table 12), though permanent employment generation was much lower in fish farms, at only 65% (Table 12).

A large proportion of the total amount of jobs were generated for youths, especially in hatcheries (44%), feed mills (41%) and middle traders/wholesalers (40%) (Table 13). Overall, employment generation benefits mostly males across all stages of the value chain (Table 13). There are practically no females occupied in the surveyed hatcheries, feed mills and fish farms, but there is much more significant job creation for females in the fish retailing stage, amounting to 32% of total job generation (Table 13).

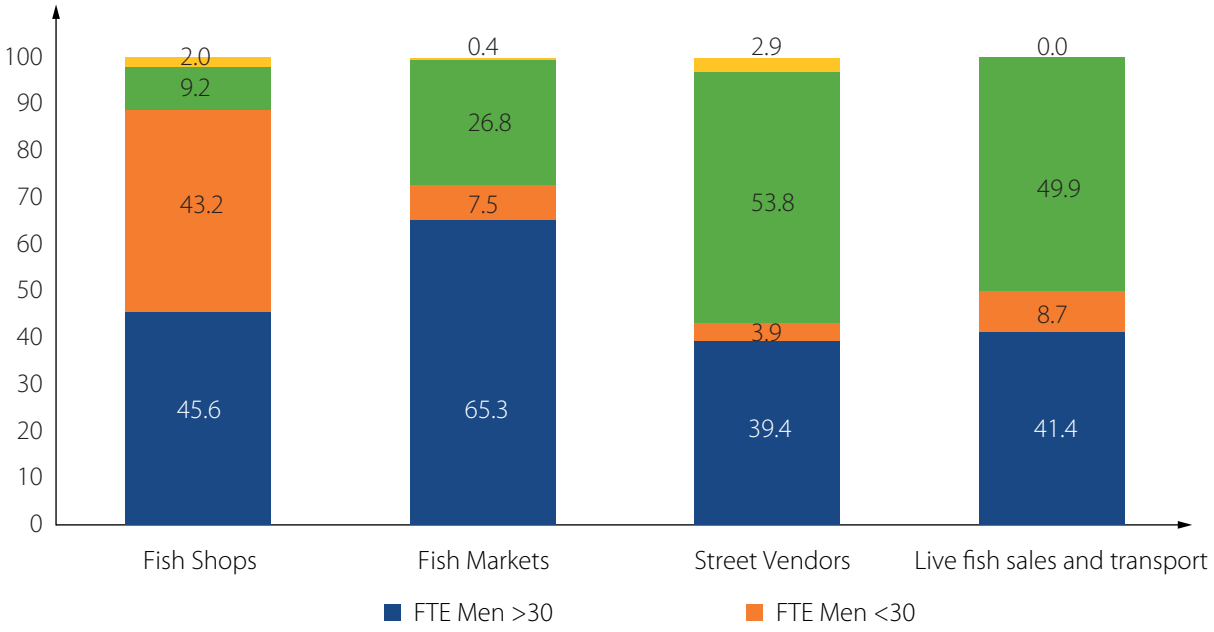



**Figure 8**. Proportion of FTE job generation by age and gender among retailers (%).

| | Behera | Fayoum | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|---|
| FTE jobs per 100 t of fish | 0.30 | 2.30 | 1.60 | 1.00 | 1.40 |
| FTE jobs men >30 per 100 t of fish | 0.20 | 1.70 | 0.70 | 0.86 | 0.82 |
| FTE jobs men<30 per 100 t of fish | 0.14 | 0.44 | 0.94 | 0.16 | 0.55 |
| FTE jobs women>30 per100 t of fish | 0.00 | 0.07 | 0.00 | 0.00 | 0.01 |
| FTE jobs women<30 per 100 t of fish | 0.00 | 0.07 | 0.00 | 0.00 | 0.01 |
| Transportation FTE jobs per 100 t of fish | 0.05 | 0.24 | 0.31 | 0.02 | 0.19 |
| FTE jobs per 100 t of fish incl. transportation | 0.35 | 2.54 | 1.91 | 1.02 | 1.59 |

**Table 9**. Employment generation indicators for fish wholesalers and middle traders.

| | Behera | Fayoum | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|---|
| FTE jobs per 100 t of fish | 10.07 | 12.67 | 5.41 | 6.5 | 7.56 |
| FTE jobs men >30 per 100 t of fish | 7.96 | 3.00 | 2.17 | 3.49 | 3.56 |
| FTE jobs men <30 per 100 t of fish | 1.00 | 4.61 | 1.09 | 0.78 | 1.57 |
| FTE jobs women >30 per 100 t of fish | 1.11 | 5.06 | 1.98 | 2.05 | 2.32 |
| FTE jobs women <30 per 100 t of fish | 0.00 | 0.00 | 0.17 | 0.19 | 0.12 |
| Transportation FTE jobs per 100 t of fish | 0.87 | 5.85 | 2.56 | 0.40 | 2.57 |
| FTE jobs per 100 t of fish incl. transportation | 10.94 | 18.52 | 7.97 | 6.90 | 10.13 |

**Table 10**. Employment generation indicators for fish retailers.

| | Behera | Fayoum | Kafr el Sheikh | Sharkia | Damietta | Average |
|---|---|---|---|---|---|---|
| **FTE in aquaculture value chain** | | | | | | |
| Hatcheries | 0.53 | NA | 0.38 | 0.26 | NA | 0.39 |
| Feed mills | 0.30 | NA | 0.22 | 0.54 | NA | 0.30 |
| Fish farms | 6.56 | 6.77 | 6.19 | 5.13 | 5.93 | 6.33 |
| Middle trader/wholesalers | 0.34 | 2.29 | 1.64 | 1.02 | NA | 1.40 |
| Retailers | 10.07 | 12.67 | 5.14 | 6.50 | NA | 7.56 |
| Total | 17.8 | 21.73 | 13.85 | 13.45 | 5.93 | 15.98 |
| **FTE in transportation activities** | | | | | | |
| Hatcheries | 0.01 | NA | 0.03 | 0.01 | NA | 0.02 |
| Feed mills | 0.05 | NA | 0.07 | 0.20 | NA | 0.09 |
| Fish farms | 0.78 | 1.08 | 0.55 | 0.50 | 0.8 | 0.7 |
| Middle trader/wholesalers | 0.05 | 0.24 | 0.31 | 0.02 | NA | 0.19 |
| Retailers | 0.87 | 5.85 | 2.56 | 0.40 | NA | 2.57 |
| Total | 1.76 | 7.16 | 3.52 | 1.13 | 0.83 | 3.58 |
| Total FTE | 19.56 | 28.89 | 17.37 | 14.58 | 6.77 | 19.56 |

**Table 11**. Employment generation across the aquaculture value chain and transportation activities (FTE jobs per 100 t of fish produced).

| | Behera | Fayoum | Kafr el Sheikh | Sharkia | Damietta | Average |
|---|---|---|---|---|---|---|
| Hatcheries | 67% | NA | 77% | 70% | NA | 75% |
| Feed mills | 85% | NA | 61% | 92% | NA | 71% |
| Fish farms | 67% | 55% | 68% | 62% | 67% | 65% |
| Middle traders/ wholesalers | 100% | 82% | 99% | 100% | NA | 96% |
| Retailers | 100% | 96.5% | 100% | 100% | NA | 99% |

**Table 12**. Permanent jobs as a fraction of total employment generation.

| | Behera | Fayoum | Kafr el Sheikh | Sharkia | Damietta | Average |
|---|---|---|---|---|---|---|
| **Youths** | | | | | | |
| Hatcheries | 57% | NA | 37% | 78% | NA | 44% |
| Feed mills | 56% | NA | 29% | 51% | NA | 41% |
| Fish farms | 37% | 26% | 36% | 33% | 25% | 33% |
| Middle traders/ wholesalers | 41% | 22% | 57% | 16% | NA | 40% |
| Retailers | 9.9% | 36.4% | 23.3% | 14.8% | NA | 22% |
| **Males** | | | | | | |
| Hatcheries | 100% | 100% | 100% | 100% | NA | 100% |
| Feed mills | 100% | 100% | 100% | 100% | NA | 100% |
| Fish farms | 100% | 100% | 100% | 100% | 100% | 100% |
| Middle traders/ wholesalers | 100% | 93.6% | 100% | 100% | 100% | 98% |
| Retailers | 89% | 60.1% | 60.2% | 65.7% | 89% | 68% |

**Table 13**. Fraction of employment generation for youth and gender.

# Discussion

## Employment generation patterns and co-benefits

This study estimates substantial employment generation across the aquaculture value chain in Egypt, in the order of 19.56 FTE jobs per 100 t of fish produced (including the employment contribution from ancillary transport services). Very few studies have attempted to estimate employment generation across the aquaculture value chain, so it is difficult to put these findings into perspective. Previous studies in Egypt have estimated that aquaculture generates 14 FTE per 100 t of fish produced (Macfadyen et al. 2011; Macfadyen et al. 2012b)490tonnes in 2009. However, these studies did not consider employment generation in hatcheries and feed mills, and had small samples from fish traders, so they have likely underestimated the total employment generation from the sector. Our estimates of employment generation from feed mills is comparable with other studies in Egypt (El-Sayed 2014; El-Sayed et al. 2015)

Regarding employment generation for females, our study reflects the findings of recent reviews and meta-analyses, which have identified that women receive lower benefits from involvement in aquaculture value chains, especially during the production stages (Mula and Sarker 2013; Sharm El-Sheikh 2015). Nonetheless, the participation of women in fish retailing is substantial—as high as 40% in some governorates, such as Fayoum (Section 4.5). This is a very promising pattern toward addressing the gender gap in the Egyptian aquaculture value chain (D'Allessandro Y. 2014).

Indeed, reports show that women perform a high proportion (40%–80%) of postharvest and marketing activities (Lentisco and Lee 2015; Harper et al. 2013; Lentisco and Alonso 2012; Weeratunge et al. 2010), suggesting potential for improvement. It is thus highly likely that the postharvest segment of the aquaculture value chain can offer the highest opportunities for achieving positive impact for women.

## Implications for meetings SDGs

As discussed above, aquaculture can catalyze employment generation across its entire value chain in Egypt, including jobs for women and youths, so it can be argued that the Egyptian aquaculture sector sits at the interface of multiple SDGs, such as SDG8 (Descent Work and Economic Growth) and SDG5 (Gender Equality). However, some of the results need to be considered critically to understand the potential of the sector to contribute to progress for these SDGs.

First, most of the generated jobs are held by people over 30 years of age. In particular, FTE job generation for this age group (FTE>30) is substantially higher across all stages of the value chain (Section 4.6). Second, males occupy most of the generated jobs (Section 4.6). Retailing is the only stage of the value chain with high employment generation for females, albeit still significantly lower than males in most governorates (Section 4.6). We did not identify any employment generation for females in the production stages of the value chain, as no female jobs were reported in the surveyed hatcheries, feed mills and fish farms. To some extent, the low employment generation for females is to be expected in fish farms, considering the manual nature of the job and the need to stay on site (and away from family) for extended periods of time. Furthermore, a significant portion of jobs in fish farms is temporary (Section 4.6) and is usually on offer during periods of high labor demand, such as harvesting. However, it is troubling to see the lack of female representation in hatcheries and feed mills, as some of these jobs are highly skilled and better paying (e.g. technical managers, feed formulation specialists, supervising engineers, quality control specialists). The lack of representation of females in these stages suggests the difficulty, for women, of obtaining higher-skilled jobs in the production stages of the value chain.

Barriers to female training might have contributed to the current lack of females occupying skilled jobs in the production stages of the sector. However, these barriers are gradually being overcome considering the greater gender balance in the newly initiated graduate courses on fisheries and aquaculture in the major Egyptian universities. It is also worth pointing out that females currently occupy 34% of research positions at the Central Laboratory for Aquaculture Research, which is part of the Agriculture Research Center, Ministry of Agriculture. While there is room for improvement, this is a very promising trend, as these are very high-skilled jobs.

It can be argued that this substantial employment generation can play an important role to ongoing efforts to meet SDG8 in Egypt. However, the lower employment generation for youths and females curbs

to some extent the contribution of the sector for progress in SDG5. It is absolutely crucial to boost the creation of employment for females and youths along the value chain to maximize the potential of the sector to become an agent of sustainable development for SDG5 and SDG8.

In the short term, the fish trading and retailing stage offers the best opportunity for job creation for females. In the medium- and long-term, the gradual growth of the sector from increasing fish production following the adoption of different intervention practices (e.g. improved fish strains, good production) can possibly boost the generation of highly skilled jobs for females and youths in hatcheries and feed mills. Fish processing offers another opportunity for the generation of skilled jobs. Currently the Egyptian aquaculture value chain has minimal value addition in terms of fish processing (Macfadyen et al. 2012b)490tonnes in 2009. Yet it has been suggested that increasing the sales of fish fillets could help to generate female employment in fish processing (Macfadyen et al. 2012a).


Fish harvest by Egyptian fish farmers in one of Kafr El-Sheikh fish farms, Egypt.

# Conclusions

This study assesses employment generation across the different stages of the aquaculture value chain in Egypt. The results suggest that aquaculture can generate significant levels of employment, amounting to 19.56 FTE jobs per 100 t of fish produced. This, combined with the ongoing growth of the sectors, means that aquaculture can contribute substantially to efforts to meet SDG8 in Egypt.

However, females and youths currently hold a relatively small fraction of these jobs. With the exception of fish retailing, jobs for females are practically nonexistent along the aquaculture value chain. It is crucial to generate more jobs for females if the aquaculture sector is to become an even more important agent of sustainable development in Egypt and contribute meaningfully to SDG5.

In the short-term, the retailing sector can offer the greatest opportunities for female job generation. However, the gradual growth of the sector needs to include plans and strategies for boosting female employment in the other stages of the value chains, and especially at the production stages, such as hatcheries and feed mills.

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# Annex

| | Behera | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|
| Average family size | 5.4 | 6.5 | 5.4 | 6.2 |
| Average hatchery size (feddan) | 3.0 | 3.9 | 2.6 | 2.8 |
| **Spawned species (in %)** | | | | |
| Tilapia | 100% | 100% | 100% | 100% |
| **Spawning unit (number)** | | | | |
| Concrete tanks | 6.40 | 39.87 | 24.00 | 33.7 |
| Hapa | 82.00 | 66.40 | 226.00 | 88.3 |
| Earth pond | 0.80 | 4.57 | 10.00 | 4.8 |
| **Size of spawning unit ($m^3$)** | | | | |
| Concrete tanks | 24.0 | 22.4 | 24.0 | 22.6 |
| Hapa | 20.3 | 21.1 | 21.8 | 21.1 |
| Earth pond | 500 | 1,654 | 260 | 1,209 |
| Total production (million seed/hatchery/yr) | 8.03 | 7.57 | 10.5 | 8.0 |
| Seed production (million seed/feddan) | 3.52 | 3.97 | 3.03 | 3.8 |
| **Production distribution (%)** | | | | |
| Fry | 93% | 91% | 100% | 93% |
| Fingerlings | 7% | 9% | | 8% |
| **Average prices (EGP/1000)** | | | | |
| Fry | 63 | 48 | 54 | 50.4 |
| Fingerlings | 150 | 153 | 0 | 153.0 |
| **Hatchery revenue (EGP/yr)** | | | | |
| Fry | 469,500 | 326,750 | 565,000 | 374,375 |
| Fingerlings | 79,500 | 146,317 | - | 119,675 |
| Brooders | 1 | - | - | 0 |
| **Total** | **549,001** | **473,067** | **565,000** | **494,050** |

**Table S1**. Production data for hatcheries.

| | Behera | Kafr El-Sheikh | Sharkia | Average |
|---|---|---|---|---|
| Average family size or respondent | 4.5 | 5.25 | 5 | 5.2 |
| Total production (1,000 t/mill/yr) | 8,500 | 12,167 | 2,667 | 9,607 |
| **Feed Production distribution (%)** | | | | |
| Pelleted | 100% | 29% | 100% | 54% |
| Extruded | 0% | 71% | 0% | 46% |
| **Start of operation** | | | | |
| After 2015 | 50% | 22% | 67% | 36% |
| Before 2015 | 50% | 78% | 33% | 64% |

**Table S2**. Production data for feed mills.

| | Behera | Fayoum | Kafr El-Sheikh | Sharkia | Damietta | Average |
|---|---|---|---|---|---|---|
| Average family size of respondent | 5.6 | 4.7 | 6.4 | 5.9 | 5.8 | 6.4 |
| Average farm area (feddan) | 27.4 | 8.8 | 14.2 | 33.7 | 33.5 | 20.2 |
| Average production (t/farm) | 136.4 | 78.4 | 63.9 | 144.5 | 131.5 | 89.0 |
| Average production (t/feddan) | 5.134 | 3.967 | 4.436 | 4.219 | 3.990 | 4.348 |
| Average sales price (EGP/kg) | 25.37 | 22.15 | 25.74 | 24.51 | 59.80 | 28.29 |
| **Species production (per feddan)** | | | | | | |
| Tilapia | 4,169 | 3,500 | 3,280 | 2,940 | 895 | 3,118 |
| Mullet (M.Cep) | 646 | 233 | 535 | 476 | 304 | 483 |
| Mullet (M.Cap) | 260 | 233 | 479 | 760 | 233 | 388 |
| Common carp | 53 | 0 | 33 | 0 | 0 | 40 |
| Silver carp | 0 | 0 | 0 | 0 | 0 | 0 |
| Catfish | 6 | 0 | 27 | 7 | 0 | 48 |
| Sea bass | 0 | 0 | 36 | 0 | 560 | 65 |
| Sea bream | 0 | 0 | 45 | 0 | 714 | 86 |
| Meagre | 0 | 0 | 0 | 0 | 929 | 82 |
| Others | 0 | 0 | 0 | 36 | 356 | 38 |
| **Total** | **5,134** | **3,967** | **4,436** | **4,219** | **3,990** | **4,348** |
| **Sales revenue (EGP/feddan)** | | | | | | |
| Tilapia | 94,603 | 70,276 | 70,432 | 59,121 | 17,190 | 68,964 |
| Mullet (M.Cep) | 25,875 | 9,326 | 21,291 | 19,207 | 12,381 | 19,261 |
| Mullet (M.Cap) | 8,857 | 3,711 | 14,129 | 23,298 | 6,583 | 11,710 |
| Common carp | 800 | 1,684 | 611 | - | - | 731 |
| Silver carp | - | - | - | - | - | - |
| Catfish | 100 | 2,852 | 473 | 76 | - | 749 |
| Sea bass | - | - | 3,091 | - | 52,143 | 5,936 |
| Sea bream | - | - | 4,136 | - | 69,286 | 8,094 |
| Meagre | - | - | - | - | 53,952 | 4,797 |
| Others | 22 | - | - | 1,724 | 27,083 | 2,765 |
| **Total** | **130,257** | **87,849** | **114,164** | **103,426** | **238,619** | **123,007** |

**Table S3**. Production data for fish farms.

WorldFish

## About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world. Headquartered in Penang, Malaysia and with regional offices across Africa, Asia and the Pacific, WorldFish is a member of CGIAR, the world's largest global partnership on agriculture research and innovation for a food secure future.

For more information, please visit www.worldfishcenter.org