



## Value chain analysis of the aquaculture feed sector in Egypt

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### ABSTRACT

This study was carried out to evaluate the value chain performance of the aquaculture feed sector in Egypt, in terms of value addition, employment and profitability. The strengths and weaknesses of each link of the value chain were assessed and appropriate upgrading, management and development strategies were suggested. Quantitative data were collected for each link in the value-chain through structured questionnaires that were drafted and distributed to the key players in the sector; 25 fish feed mills and 34 fish farms covering different geographical and production regions.

The results indicated that the Egyptian aquafeed value-chain is relatively simple; including only four main stakeholder groups. These are feed input suppliers, aquafeed producers, aquafeed marketers and traders and fish farmers. Between 50 and 99% of feed ingredients used in aquafeed production in Egypt are imported. About 90% of Egyptian aquafeeds are produced by the private sector in the form of conventionally pressed, pelleted feeds (80–85%) and extruded feeds (15–20%). About 85% of those producers sell their feeds directly to farmers with payment either in cash or on credit, while the remaining 15% sell through intermediaries such as traders. State-owned mills produced only 10% of total commercial fish feed production in 2012, exclusively in the form of pressed, pelleted feeds. Employment generation in private sector feed mills was 29.2 full-time equivalent (FTE) jobs per mill, with an average of 3.9 jobs per 1000 tonnes of feed produced. Employment generation in state-owned mills was much higher; with an average of 90.3 FTE per mill. Males represented 90% of the full-time employment in the state-owned mills and 96.6% in the private sector. Feed costs represent 75–90% of the total operating costs of the fish farms. The major factors impacting on the performance of the value-chain relate to inputs, to feed production, to fish farmers and to marketing and financial services. The study recommends actions to mitigate these issues including the local production of more feed raw materials, strengthening quality control and inspection, providing training for feed mills, better organization of fish farmers and improving the legal and policy environment.

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### 1. Introduction

The Egyptian aquaculture sector has witnessed rapid expansion over the past two decades. As a result, farmed fish production increased from only 63,895 tonnes in 1992, representing 18.5% of total Egyptian fish production to reach 1,017,738 tonnes in 2012, contributing 74% to total production (FAO, 2013; GAFRD, 2014). Meanwhile the farmed area has increased from about 42,000 ha in 1999 (El-Sayed, 1999) to 120,000 ha in 2012 (GAFRD, 2014).

Aquaculture expansion in Egypt has been accompanied by a gradual shift from extensive and semi-intensive low input culture systems to more intensive, feed-dependent systems. This approach has in turn increased the demand for commercial fish feeds resulting in the number

of fish feed mills increasing from only 5 state-owned mills producing about 20,000 tonnes per year in 1999 (El-Sayed, 1999) to over 31 mills in 2009 with an estimated production of 420,000 tonnes (El-Sayed, 2013). The investment of the private sector in fish feed industry has sharply increased over the past few years. However, the value chain of aquafeed sector has not yet been mapped and the key players have not been clearly identified and characterized. Therefore, the value chain performance of the Egyptian aquafeed industry is not well understood.

A value chain is a chain of activities and services required to bring a product or service from its conception to final customers, and final disposal after use (Hellin and Meijer, 2006; Kaplinsky and Morris, 2000). Value chains include input suppliers, producers, processors and buyers. They are supported by a range of technical, business and financial service providers. Value Chain Analysis (VCA) is a diagnostic tool, defined by Taylor (2005) as a “multi-dimensional assessment of the performance of value chains, including the analysis of product flows, information flows and the management and control of the value chain”. Such analysis draws

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the attention of the different stakeholders to the opportunities for improvement at different stages in the value chain.

Value-chain analysis (VCA) has been proved to be a useful means to assess performance in different systems including (Macfadyen et al., 2012):

- Distributional issues and pro-poor and gender equitable growth (Mayoux and Mackie, 2008; Rubin et al., 2009; USAID, 2011);
- The relative importance of factors affecting competitiveness, and the costs and earnings of each cycle of the value chain;
- Identifying and analyzing gaps and weaknesses in value chain performance; and
- Identifying and suggesting appropriate upgrading, management and development strategies to improve value chain performance.

The prominence of VCA as a useful tool of analysis in the fisheries, aquaculture and aquafeed sectors has increased during recent years (Christensen et al., 2011; Macfadyen et al., 2012; Mamun-Ur-Rashid et al., 2013; Nasr-Allah et al., 2014; Veliu et al., 2009).

This study was carried out in 2013 to analyze the aquaculture feed value-chain in Egypt. The overall objectives of the study were to: 1) map the value-chain for fish feed industry; 2) describe the main actors and stakeholders within the chain; 3) determine value chain performance; 4) identify and synthesize the strengths and weaknesses of each link of the value-chain; and 5) suggest appropriate upgrading,<sup>1</sup> management and development strategies. The study was carried out by a consultancy team organized by WorldFish under the Improving Employment and Incomes through Development of Egypt's Aquaculture Sector (IEIDEAS) project funded by the Swiss Agency for Development and Cooperation.

## 2. Materials and methods

### 2.1. Data collection

Two structured questionnaires were drafted; one for fish feed producers and one for fish farmers. These two stakeholders are the key players along the aquaculture feed value chain in Egypt. Initially, a third questionnaire was prepared for traders/retailers. However, it was decided not to use it because: 1) about 85% of fish feed producers sell their products directly to farmers, and only 15% sell to traders or retailers; 2) traders sometimes practice fish farming; 3) most fish feed traders also sell other animal feeds and feed ingredients, they do not separate fish feed sales from animal feed sales and fish feeds often represent an insignificant proportion of their total sales; and 4) the traders approached refused to provide any information about their sales.

In order to avoid a poor response, selected stakeholders were first approached by phone, e-mails, or through trusted intermediaries. They were briefed about the study questionnaire and asked whether they were willing to participate in the study. If they agreed, the appropriate questionnaire was administered and completed by project staff through personal interviews, phone calls, faxes or e-mails or through the trusted intermediaries.

Sampling was designed to reflect all the value chain links and cover factors that might affect value chain performance. For aquaculture feed producers, sampling was designed to cover most of the geographical areas where aquaculture feed production is located. Sampling also included a range of small, medium and large producers from both private sector and state-owned/public sector. Random samples of fish feeds were also collected from different mills in different geographical areas for subsequent feed quality assessment by proximate analysis.

<sup>1</sup> Upgrading means acquiring the technological, institutional and market capabilities to improve the sector's competitiveness and profitability.

For fish producers, sampling was also designed to cover small (2–<10 ha), medium (10–20 ha) and large-scale fish farms (>20 ha), particularly in the major production governorates. All farming systems including semi-intensive pond farms and intensive (tanks, ponds and cages) farms were covered. Farmers of different ages, educational backgrounds and marital status were interviewed.

Secondary information was collected from various sources, including the General Authority for Fisheries Resources Development (GAFRD), the Food and Agriculture Organization of the United Nations (FAO), the Central Agency for Public Mobilization and Statistics (CAPMAS), aquaculture and aquafeed consultants and decision makers. All data on the financial performance of the value chain collected and presented in this paper pertain to the full calendar year 2012, and are yearly averages.

### 2.2. Data analysis

Twenty five fish feed producers were interviewed, 17 from the private sector and 8 belonging to the state-owned sector (Table 1). Thirty four fish farmers representing a range of production systems and aquaculture areas also responded to the questionnaire (Table 2). The information obtained from the surveys was collated, tabulated and sorted into different categories. Feed mills were categorized according to ownership, production capacity and the type of feed produced, while fish farms were sorted according to the farming system adopted, culture environment (fresh water, brackish water and sea water) and cultured species. All data were coded and entered into a Microsoft Excel spreadsheet for statistical analysis, primarily comprising simple descriptive statistics.

### 2.3. Data validation

Due to significant variability in the data collected for the different variables between state-owned/public feed mills and private mills, the data of these two subsectors were analyzed separately. Variations and differences observed between individual responses and between overall financial performances within each subsector were minimal. This was attributed to the large sample sizes and the well-designed and simple questionnaires which helped the research team collect all the necessary data and also assisted the interviewed stakeholders to readily answer all the questions. Data cleaning was not necessary, meaning that the quality of data collected was high.

## 3. Results and discussion

### 3.1. Value chain mapping

The value-chain of the fish feed sector in Egypt is relatively simple. As shown in Fig. 1 it includes four main stakeholder groups; namely:

1. Feed input suppliers; control the supply of imported and locally produced feed raw materials to feed mills.
2. Feed producers; responsible for converting the feed raw materials into pelleted feeds to be used by fish farmers.
3. Feed marketers and traders; buy feeds from the feed mills and sell to the fish farmers, often offering credit.
4. Fish farmers; use the feeds bought from the feed mills or traders to feed their fish.

**Table 1**  
Number of feed mills interviewed according to ownership and production capacity.

| Ownership      | Production range (1000 tonnes/ mill/year) |      |       |       |     | Total |
|----------------|---|------|-------|-------|-----|-------|
|                | <5  | 5–10 | 10–15 | 15–20 | >20 |       |
| Public sector  | 3   | 2    | 1     | -     | 2   | 8     |
| Private sector | 3   | 4    | 4     | 3     | 3   | 17    |
| Total          | 6   | 6    | 5     | 3     | 5   | 25    |

**Table 2**  
Number of fish feed mills and number fish farms interviewed according to production system and governorate.

| Governorate           | Feed mills | Semi-intensive | Intensive |       |       | Total farms |
|-----------------------|------------|----------------|-----------|-------|-------|-------------|
|                       |            |                | Ponds     | Tanks | cages |             |
| Kafr El-Sheikh        | 6          | 11             |           | 1     | 2     | 14          |
| Beheira               | 4          | 6              | 1         |       | 3     | 10          |
| Dakahlia <sup>1</sup> | 5          | 2              |           |       |       | 2           |
| Sharkia               | 2          |                |           | 1     |       | 1           |
| Alexandria            | 1          | 2              |           |       | 2     | 4           |
| Domiat                | 2          | 1              |           |       | 1     | 2           |
| Port Said             |            | 1              |           |       |       | 1           |
| Giza                  | 2          |                |           |       |       |             |
| Cairo                 | 1          |                |           |       |       |             |
| Gharbia               | 1          |                |           |       |       |             |
| Ismailia              | 1          |                |           |       |       |             |
| Total                 | 25         | 23             | 1         | 2     | 8     | 34          |

<sup>1</sup> The Industrial Zone at Asafra, Dakahlia is the major fish feed production centre for dakahlia and other Neighboring governorates.

There is no business support organization for Egyptian aquaculture feed producers. The relevant regulatory authority for the aquaculture industry is the Ministry of Agriculture and Land Reclamation. Ministry of Industry and Trade specifies and regulates the import of aquaculture inputs, the Ministry of Finance regulates import and export tariffs and fees and the Ministry of Manpower and Immigration and Ministry of Social Solidarity have responsibilities towards the care of the labourers working in aquafeed industry.

Machinery and hardware providers were excluded from the mapping exercise because all the equipment is imported from a wide range of sources and at different times making it extremely difficult to collect information about this component. However, the feed millers' questionnaire contained questions regarding machinery importation, installation, maintenance and hardware availability. The responses suggest that, while capital costs are important, maintenance costs for equipment play a relatively insignificant role in overall operating costs.

### 3.2. Fish feed raw materials

#### 3.2.1. Locally produced raw materials

The main protein sources used for fish feed production in Egypt are soybean meal (SBM) (included at 20–40%) and fish meal<sup>2</sup> (3–22%). Other protein sources such as cotton seed meal (CSM), meat and bone meal and poultry by-product meal are occasionally included at much lower levels. Major dietary energy sources are generally included at the following levels: yellow corn (10–35%), wheat bran (20–30%), rice bran (10–25%) and vegetable oils (1–5%). The inclusion levels of these ingredients depend on the protein and energy contents of the feed, the availability and prices of the ingredients and fish species and sizes.

Egyptian production of major feed ingredients currently used for animal feed and aquafeed production is far from meeting local demand. In addition, the production of some oil seeds (such as linseed, cottonseed and soybean) has been decreasing since 2004.

#### 3.2.2. Imported raw materials

Depending on the formulations used, between 50% and 99% of feed ingredients used in aquafeed production in Egypt are imported (FAO, 2013; Tacon et al., 2012). As international prices for feed raw materials have risen and with a declining exchange rate for the Egyptian pound against major currencies, prices of feed ingredients and processed feeds have increased substantially in recent years. For example, between 2002 and 2011, the quantities of the major imported feed ingredients increased from 12 million tonnes to over 19 million tonnes, a 65% increase in imports. In 2011, 99% of soybean cake, 97% of soybean

seeds, 89% of sunflower oil, 67% of sunflower cake, 53% wheat and 50% of maize used in Egypt were imported. Also the unit prices (\$US/tonne) of these ingredients in Egypt have increased sharply; by 280% for soybean seeds, 206% for soybean oil, 170% for sunflower oil, 147% of maize and 123% for wheat over the period from 2002 to 2011 (FAO, 2013).

Feed raw material imports are carried out mainly by the private sector with a few large importers monopolizing the market by controlling the supply and prices. All fish feed millers interviewed buy their ingredients directly from these importers. Various local suppliers and traders also deliver ingredients to small feed producers. However, the research team failed to get sufficient information on the amounts of fish feed ingredients sold by local traders/suppliers, because they sell feed ingredients not only to fish feed millers, but also to other animal feed producers (i.e. poultry and livestock feeds). They claimed that they do not have separate records of the amounts sold for fish feed production.

#### 3.2.3. Feed additives

Feed additives, vitamins and mineral premixes are locally produced, mainly by pharmaceutical companies and feed additives companies. Fish feed millers buy their feed additives either directly from these two sources or from additives suppliers/retailers. Twenty seven percent of the interviewed private sector millers reported that they have premixes/additives production lines inside their mills. They generally buy the ingredients separately (in bulk) from local suppliers and formulate their own additives. The prices of feed additives vary significantly depending on the ingredients contained in these additives.

In the public sector, the feed millers interviewed purchase additives from local suppliers through holding companies. Two millers acknowledged that they only incorporate additives upon farmers' request which leads to higher feed prices.

### 3.3. Fish feed production

Fish feeds in Egypt are produced by both public sector/ state-owned holding companies and by the private sector. There is no official data source on current fish feed production and the number of feed mills. However, the number of fish feed mills was estimated at 31 in 2009, 11 belonging to the government/public sector and 20 owned by the private sector, with a production capacity of about 420,000 tonnes/year (El-Sayed, 2013). Based on current research these were under-estimates as the number of registered feed mills identified in this study was much higher (60 mills), with annual production capacity of about 770,000 tonnes.

#### 3.3.1. Government/public sector mills

There are currently 9 government/public sector mills producing fish feeds in Egypt with total production of around 100,000 tonnes in 2012. Two mills are owned by the General Authority for Fisheries Resources Development (GAFRD), a division of the Ministry of Agriculture and Land Reclamation (MALR) and 7 are owned by the Egyptian Holding Company for Food Industries (EHCFI). The GAFRD mills produce only fish feeds while the EHCFI mills produce fish and other animal feeds. Three of the EHCFI mills belong to the Oils and Soaps Company and 4 mills belong to the Rice Milling Company. All the feed produced is in the form of conventionally pelleted (sinking) feeds, and most is formulated to contain 25% crude protein (CP). Only a small proportion (3–5%) of their production was formulated to contain 17–18% CP and was produced upon farmer's request.

Most of government/public sector mills work 2–3 shifts per day, depending on market demand. Yet, the average production of these mills in 2012 represented only 53% of their total annual production capacity. The operational data of state-owned (and private mills) is summarized in Table 3.

<sup>2</sup> All the feed mills interviewed for the study stated that they used fish meal in their feeds.



**Fig. 1.** The Egyptian aquaculture feed value chain.

### 3.3.2. Private mills

There are at least 50 registered private sector feed mills distributed across the country producing around 670,000 tonnes of conventionally pelleted and extruded feeds for freshwater and marine fish species in 2012. About 30 of these were in industrial zones, particularly in Balteem (Kafr El-Sheikh governorate) and Manzala (Dakahlia governorate).

The amount of feeds produced by the private sector mills in 2012 represented 79% of their potential production capacity. The majority of these mills (68%) work one shift (8 h) per day, 27% work two shifts, while only 5% work three shifts. The fish feed production season lasts for 6-8 months (April/May–October/November), paralleling the seasonal nature of aquaculture production systems in Egypt. During the winter (December–March) the main farmed fish species including tilapia, mullet and African catfish do not eat, due to cold water temperatures so fish feed production lines stop operating at this time.

About 80–85% of fish feed produced is in the form of conventionally pelleted feed while the remaining 15–20% was extruded (floating) feeds. Only a few of the private sector feed mills (5 mills in 2012) produce extruded feeds as this requires specialized production lines. The proportion of extruded feed produced by individual companies varied from 20% to 80% of their 2012 production.

Over 95% of the feeds produced by the private sector were formulated to contain 25% crude protein (CP), while the remaining 5% contained either 30%, 32% or 35% CP, generally produced on request. In addition, a few tonnes of feed containing >40% CP are also produced for larval feeding and/or marine fish feeding. Most (over 90%) of the feed producers said they do not produce larval feeds because it is such a small market as very small amounts of feed are required during early growth stages. More often processed grow-out feeds are ground into powder-like meals and used for feeding fish larvae.

**Table 3**  
Operational data of fish feed production and trading in Egypt in 2012.

| Operational data   | Public sector | Private sector |
|--|---------------|----------------|
| No. of mills interviewed                                 | 8             | 17             |
| Average annual production (tonnes)/mill                  | 10,800        | 13,400         |
| % of production to total production capacity             | 53            | 79             |
| % of compressed feed of total feed produced              | 100           | 80             |
| Average sale price (USD/tonne) of 25% cp compressed feed | 510           | 550            |
| Average sale price (USD/tonne) of 25% cp extruded feed   | -             | 665            |
| Average sale price (USD/tonne) of 30% cp extruded feed   | -             | 708            |
| Average profit margin (%) for 25% cp feed                | 4.5           | 7.8            |
| Average number of FTE per mill                           | 90.3          | 29.2           |
| Average No. of temporary jobs/mill                       | 5.75          | 8.9            |
| Average FTE per 1000 tonnes of feed produced             | 13.3          | 3.9            |
| % of administration jobs                                 | 33.3          | 17.5           |
| % of FTE female jobs                                     | 10            | 3.4            |
| No. of working shifts per day                            | 2–3           | 1–2            |
| % of feed sales directly to fish farmers                 | 30            | 85             |
| % of sales to traders/retailers                          | 70            | 15             |
| % Profit margins of traders                              | 3–5           | 3–6            |

There are also a significant number of unregistered, small-scale pelletizing units. While their number was previously estimated at 50, each with an annual production capacity of 3,000 to 4,000 tonnes of fish feed, representing total annual production of 120,000–240,000 tonnes (El-Naggar et al., 2011; cited in Macfadyen et al., 2011), current estimates suggested that the number of non-registered fish feed mills has increased dramatically during the past few years to over 200 units. These milling units are generally locally made, use simple technologies and are usually not equipped with pellet driers. In addition, many farmers simply rent a feed mill, often without a specific line for fish feed production, costing around \$US 20–30 per tonne (El-Naggar et al., 2011). The farmer buys the ingredients and provides the feed formulation, leading to significant cost savings (estimated at 10–15% of feed costs).

### 3.3.3. Total feed production

The average annual fish feed production in registered private sector feed mills in 2012 was estimated at 13,400 tonnes/mill. Therefore, the total volume of feed produced by the 50 registered private mills was around 670,000 tonnes. If nonregistered mills and feeds produced by the farmers themselves are considered, total production of fish feeds from private sector feed mills was around 800,000 – 900,000 tonnes in 2012. Including the estimated 100,000 tonnes from public sector mills suggests that total annual fish feed production is around one million tonnes per year.

### 3.4. Investment in fish feed manufacturing

Establishing a commercial fish feed mill requires high investment for initial infrastructure and machinery set-up and subsequent running expenditure to operate the mill. Skilled labour and professional management are also necessary for establishing and running commercial fish feed enterprises. It was very difficult for the research team to obtain sufficient information on the investment in fish feed manufacturing, particularly capital investment, from the interviewed feed millers. Only two feed manufacturers provided full details on the capital and running costs of their mills (Table 4). The rest of the producers provided scattered information on the operational expenses, only as percentage of total running costs.

### 3.5. Employment

#### 3.5.1. Government/public sector feed mills

The employment rate in fish feed production varies significantly between public and private sector mills (Table 3). In the governmental/public sector mills, the number of permanent jobs ranged from 36 to 106 persons per mill with an average of 90.3 jobs/mill. Female jobs

**Table 4**  
Operational and capital costs of small and medium scale feed mills in 2012.

| Item                       | Small-scale mill<br>(5000 tonnes/year) |                          | Medium-scale mill<br>(15,000 tonnes/year) |                          |
|----------------------------|--|--------------------------|---|--------------------------|
|                            | Cost (US\$) <sup>1</sup>               | % of total running costs | Cost (US\$) <sup>1</sup>                  | % of total running costs |
| <i>Running costs</i>       |  |                          |   |                          |
| Feed ingredients           | 1,415,100                              | 94.13                    | 2,751,572.0                               | 87.90                    |
| Premixes and additives     | 23,585.0                               | 1.57                     | 235,849.0                                 | 7.53                     |
| Transportation and storage | 13,364.8                               | 0.89                     | 62,893.0                                  | 2.00                     |
| Electricity and fuel       | 13,993.7                               | 0.93                     | 31,446.5                                  | 1.00                     |
| Labour and management      | 29,874.2                               | 1.99                     | 24,371.0                                  | 0.78                     |
| Hardware and maintenance   | 6,289.3                                | 0.40                     | 7861.6                                    | 0.25                     |
| Other costs                | 1,415.1                                | 0.09                     | 16,195.9                                  | 0.52                     |
| Total running costs        | 1,503,322.1                            | 100.0                    | 3,130,189.0                               | 100.0                    |
| <i>Capital costs</i>       |  |                          |   |                          |
| Depreciation               | 25,723.3                               |                          | 257,300                                   |                          |
| Taxes                      | 15,000                                 |                          | 16,600                                    |                          |
| Total fixed costs          | 40,723.3                               |                          | 273,900                                   |                          |
| Total costs                | 1,544,045.4                            |                          | 3,404,089                                 |                          |
| Total revenue              | 1,650,094.0                            |                          | 3,609,183                                 |                          |
| Net profit                 | 106,048.6                              |                          | 205,094.0                                 |                          |
| % of profit to total costs | 6.9%                                   |                          | 6.02%                                     |                          |

<sup>1</sup> One US\$ = 6.36 Egyptian Pound in 2012.

represented 10% of the total permanent employment and the average number of temporary jobs was 5.75 jobs/mill. The ratio of administrative jobs to production-related jobs is extremely high in the public sector; ranging from 13 to 60% with an average of 33.3% of total permanent jobs. Most of interviewees acknowledged that employment in both administrative and technical divisions is much greater than is needed. Direct employment in public sector mills in 2012 was 13.3 full-time equivalents (FTE) for every 1000 tonnes of feed produced.

It should be emphasized that the workers get their salaries paid throughout the whole year, despite the fact that the production season extends for only 6–8 months of the year to match from fish farms during the growing season (April/May–October). As a result, profit margins of public sector feed mills are relatively low (\$US 27/tonne).

#### 3.5.2. Private sector feed mills

The employment rate in private sector fish feed mills was much lower than in public sector ranging from 3 to 110 persons per mill with an average of 29.2 jobs/mill. Female jobs represented 3.4% of total permanent employment and the average number of temporary jobs was 8.9 jobs/mill. Administrative jobs in the private sector in 2012 represented 17.5% in average of the total permanent jobs, almost half of the percentage of administrative jobs in public sector mills. Similarly, direct employment in private sector feed mills was only 3.9 FTE for every 1,000 tonnes of fish feeds produced and much lower than the equivalent figure of 13.3 FTE/1000 tonnes in public sector mills. Thus, profit margins in private sector feed mills (average \$US 38/tonne) tend to be higher than those in public sector mills.

### 3.6. Feed marketing and trading

#### 3.6.1. Market share

Fig. 2 illustrates market shares between the different stakeholders. Around 85% of private sector fish feed producers sell their products directly to farmers, and only 15% to traders or retailers. Traders are sometimes also fish farmers, but sell feed as an additional source of income with a mark-up of 2–5% (average 3.7%). Many small-scale fish farmers purchase feed from the mills or traders on credit (3–6% higher price), or pay 50% of the price in cash and pay the rest on credit until after the fish are harvested and sold. However, when farmers take credit

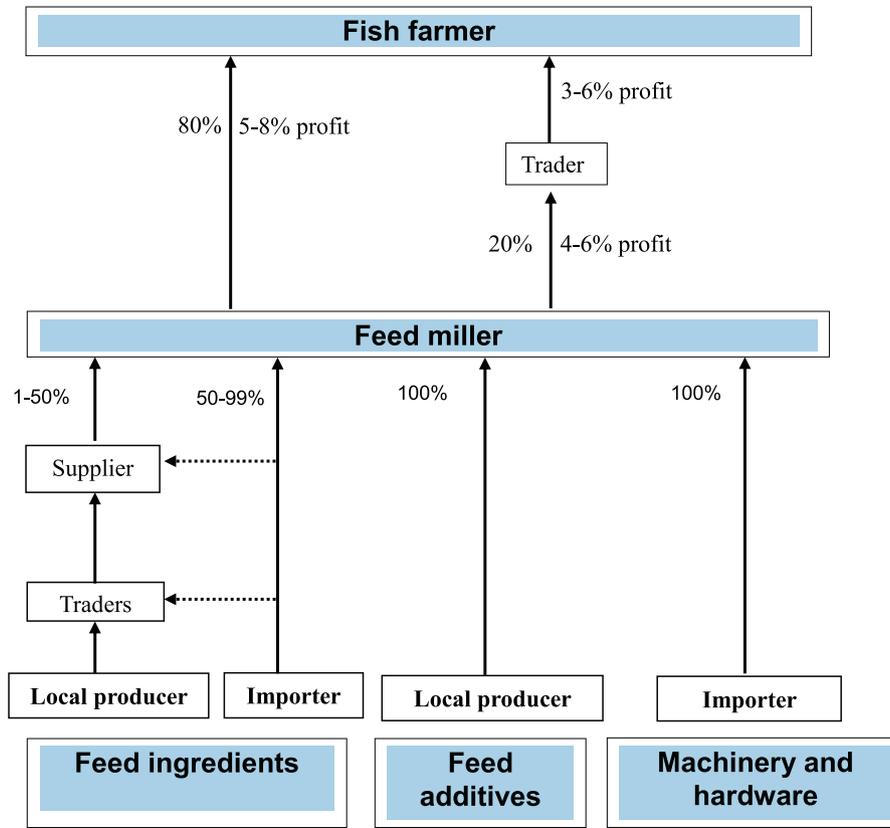


Fig. 2. Market share and profitability in the fish feed value chain.

they may receive poor quality feed, but have little bargaining power to complain or object.

In state-owned/public sector feed mills about 70% of produced feeds go to traders, and only 30% are sold to the farmers directly. This is because a credit-based system is very difficult to apply in the public sector. Public mills generally ask for specific guarantees such as fixed assets, movable assets or savings certificates, which most small-scale farmers are not able to provide, making feed marketing one of the most serious problems facing public sector fish feed mills.

Over the past decade, prices of conventionally pelleted tilapia feeds in Egypt have risen sharply from US\$ 260/tonne (25% CP) in 2003 to \$ 510/tonne in the public sector and \$ 550/tonne for the private sector in 2012. Similarly, prices for extruded feeds have more than doubled, from \$300/tonne in 2003 to \$ 665/tonne for 25% CP feed and to \$ 708/tonne for 30% CP feed in 2012. While sharp increases in feed ingredient prices, especially for imported ingredients such as fish meal, soybean meal, corn, wheat bran and oils are behind the price rises, current prices are also in line with the average rate of inflation which was around 10% per year over this period. The higher price for extruded feeds compared to conventionally pelleted feeds is because of the high costs of installing and operating extruders. Egyptian fish feed prices are still lower than in most African countries (Table 5) which means that fish feed exports could be feasible.

3.6.2. Feed packaging, transportation and storage

Most Egyptian commercial fish feeds are packed in 25 kg polypropylene bags, which are closed mechanically with either string or heat sealing. Bagged feeds are generally stored for relatively short periods (maximum of 1-2 weeks) in shaded, well aerated stores, complying with the Code of Practice for Good Animal Feeding (FAO, 1998). However, some factories (especially public sector mills and small-scale mills) lack appropriate storage facilities for ingredients and finished feeds. Although the feed prices

from the larger mills may be higher than those from the government-run mills, many fish farmers prefer to buy from them. In other words, farmers are willing to pay a premium for quality.

Large scale feed producers generally use their own vehicles for feed transportation, especially when a large amount is being sold. In large mills feed is loaded on the trucks automatically, while in small- and medium-scale mills, feeds are loaded manually. On the other hand, small farmers, who generally buy small amounts of feed, use their own or rented trucks. Farmers from the same area sometimes cooperate to rent a truck if they are buying from the same mill. A margin of 1–2% is added to the feed price to cover delivery costs, depending on the distance and the amount.

Table 5  
Fish feed prices in some African countries.

|                                  | Cultured species     | Feed type | Protein content (%) | Price (USD/mt) |
|----------------------------------|----------------------|-----------|---------------------|----------------|
| Egypt <sup>1</sup>               | Tilapia              | Pressed   | 25                  | 550            |
|                                  |                      | Extruded  | 25                  | 665            |
|                                  |                      | Extruded  | 30                  | 708            |
| South Africa <sup>2</sup>        | Tilapia              | Extruded  | 30                  | 720            |
| South Africa (2013) <sup>3</sup> | Tilapia              | Extruded  | 30                  | 780            |
|                                  | Tilapia              | Extruded  | 32-35               | 860-960        |
| Ghana <sup>4</sup>               | Farmed fish          | Extruded  | 40                  | 1038           |
|                                  |                      | Extruded  | 28-30               | 770-850        |
| Nigeria (local) <sup>4</sup>     | Cultured fish        | Extruded  | 42                  | 1250-1500      |
|                                  |                      | Extruded  | NA*                 | 1666           |
| Nigeria (imported) <sup>4</sup>  | Cultured fish        | Extruded  | NA                  | 2420           |
| Uganda (2010) <sup>4</sup>       | Tilapia/catfish/carp | Extruded  | 30                  | 590            |
|                                  |                      | Extruded  | 35                  | 727            |

<sup>1</sup>Current study (prices not deflated for sake of comparison); <sup>2</sup> L.T. Morshuizen (Personal contact, 2014); <sup>3</sup> L. de Wet (Personal contact, 2014); <sup>4</sup>Cocker (2014). \*Not available.

### 3.7. Fish farmers

The fish farmers interviewed during this study acknowledged that the quality and price of fish feed is very important as it comprises 75–95% of total operating costs. This makes escalating feed prices a serious problem. Lack of access to credit has been considered as one of the major constraints facing Egyptian fish farmers for many years (El-Gayar, 2003; El-Naggar et al., 2008; Zwirn, 2002). Both state-owned banks and private banks are reluctant to finance aquaculture enterprises, especially small-scale businesses. No insurance system is currently available in Egypt for fish farmers. Therefore, only large aquaculture enterprises are able to obtain credit from the formal financial sector.

As a result, many small-scale fish farmers purchase processed feeds, feed ingredients and feed additives from the producers or traders on credit. Only 31% of interviewed fish farmers, mostly larger farmers, pay for their feed in cash, whereas 44% purchase on credit. A further 25% said they use a partial payment system, where the farmer pays 50% of the price in cash and pays the rest after harvesting and selling their fish crop. About 15% of the interviewed farmers, particularly small-scale farmers who adopt credit or partial payment systems, reported also that they sometimes receive poor quality feed (i.e. high dust or moisture levels and low pellet durability). This claim has been supported by proximate analysis of random samples of different fish feeds used by different farmers in different geographical areas. These analyses indicated that the quality of the feed produced by many private mills was poor.

About 60% of semi-intensive fish farmers reported that they use pond fertilization in addition to supplementary feeding. Both organic fertilizers (usually poultry manure) and inorganic fertilizers, (urea, superphosphate (SP) and triple superphosphate (TSP)), are widely used. The farmers said this leads to significant decreases in running costs and also improves feed utilization efficiency due to the contribution of natural food to pond production. Normal practice is to fertilize ponds before and just after stocking with fish. As the fish grow, water exchange increases, making pond fertilization less important.

### 3.8. Services

#### 3.8.1. Quality control inspection

Ninety percent of public sector mills regularly conduct proximate analysis of the feed ingredients and compound feeds in the laboratories of the Ministry of Agriculture and Land Reclamation (MALR). Only one mill (Behaira Rice Milling Co. in Dalangat) carries out proximate analysis in its own lab. In the private sector, 45% of feed producers said they run proximate analysis in private laboratories/public laboratories (universities, MALR and private labs) while 35% have their own facilities and the remaining 20% said they do not analyse their feeds. Sixty per cent of mills said they receive no extension advice or quality control inspection from government authorities or non-governmental organizations (NGO) while 40% said they receive these services regularly or occasionally.

Proximate analysis of randomly collected feed samples indicated that there were quality problems with the feed produced by some of the private mills. Only 43% of the analyzed samples matched the declared 25% protein content on the labels while the rest of the samples contained much lower protein levels (20.5 to 23.2%). The lipid content of some samples was also very low (3%), while the fiber content was high (>15%). Similarly, the moisture content of some feeds was also relatively high (>12%). High moisture levels combined with high temperatures (>25 °C) favor the growth of molds which can produce mycotoxins such as aflatoxins with damaging impacts on farmed fish. Contamination of Egyptian feed ingredients such as maize, rice germ, rice bran, wheat bran, and cotton seed cake with aflatoxins has been previously recorded (Abdelhamid, 1990). Poor storage and transportation of feed ingredients and processed feeds, could lead to serious deterioration of the quality of these feed sources. Egypt has a standard regulating

mycotoxins in human food (Egyptian Standard UDC 615.91. Maximum Limits for Mycotoxin. In Foods, Part I: Aflatoxin). However, no such standard is applied to animal feeds.

Egypt adopted Ministerial Resolution 1498 (1996) (amended by Resolution 1056 (1999) and Resolution 1057) regulating animal feed, feed production, circulation and control and technical permission required for importing feeds, feed ingredients and feed additives. However, there is no specific legislation or provisions on fish feed manufacturing in Egypt. Until appropriate legislation is issued, Resolutions 1498 (1996), 1056 and 1057 (1999) could be adopted. These resolutions contain sufficient provisions and articles that can be applied for regulation and quality control inspection of aquafeeds.

#### 3.8.2. Financial services

As stated earlier, no insurance system is currently available for Egyptian fish farmers, despite the recent emergence of a global aquaculture insurance market (Anrooy et al., 2006; Naziri, 2011). Consequently, fish farmers, especially small farmers, have poor access to formal credit and financial support and makes government and private sector banks reluctant to finance aquaculture enterprises. As a result, small farmers purchase farming inputs, including processed feeds, feed ingredients and feed additives from producers or traders on credit, at higher prices and at more risk of being supplied with poor quality feed.

#### 3.8.3. Extension services and capacity building

Over 80% of fish feed millers, technicians and engineers said they have received no capacity building training by government or private sector organizations although the majority of them claimed that they need such training to improve their skills, and to update them with recent fish feed production and management technologies. In addition, all of the farmers interviewed said that they do not receive any training, capacity building or government extension assistance with regards to aquaculture, fish nutrition, feed and feeding management. Most of the farmers also lack basic knowledge about feed management, feeding practices and strategies so they most likely use feed incorrectly. It is thus no surprise that the feed conversion ratio (FCR) of most semi-intensive pond farms fed with 25% CP conventionally pelleted feed was greater than 2:1 whereas it should have been much lower (1–1.5:1).

#### 3.8.4. Role of producer organizations

There are 10 aquaculture cooperatives in Egypt, distributed across the major production governorates and affiliated to a national apex body, the Union of Aquatic Cooperatives which includes both aquaculture and fisheries coops. The aquaculture coops were established to provide a link between the regulatory authorities and their members providing services such as representation for fish farmers, sourcing government loans, providing technical and legal services, resolving over fish farm leases and establishing water use rights. However, most aquaculture coops are either not functioning or provide minimal services to a few fish farmers. With the exception of Fayoum Fish Farmers Association (FFFA) these associations play no role in providing fish feed services to fish farmers. In Fayoum, the FFFA buys good quality feed in bulk for its members, through an annual tender process with price savings on bulk orders. It also operates a credit system where the farmers pay up-front for only 50% of their annual feed costs and the rest is paid on credit, or through monthly payments, without an increase in price. This reduces the need for farmers to obtain credit from feed traders, thereby reducing the risk of being provided with poor quality feed. FFFA also buys other production inputs such as fish seed, additives, drugs, premixes, water quality analysis equipment in bulk and sells them to the farmers at promotional prices; very often on credit (M. Gouda, chairman of FFFA, personal communication, 2013).

### 3.9. Critical factors and suggested actions

#### 3.9.1. Critical factors

The following issues were identified as critical factors affecting the performance of the Egyptian aquaculture feed sector:

1. Dependence on imported feed ingredients. Prices of feed ingredients have been increasing in both global and consequently domestic markets and the trend is set to continue. Furthermore, trade is monopolized by a few large importers who control the supply and price. Many feed producers complained that there are continuous fluctuations in the availability and quality of the ingredients they receive from the importers.
2. Limited capacity for production of high quality feeds. Many private and public mills are producing poor quality feeds, mainly due to the use of old technology and/or lack of quality control. Over 80% of Egyptian aquaculture feed is conventionally pelleted. If poorly formulated, processed and applied the use of these feeds can lead to low feed efficiency and substantial waste; this study found that the average feed conversion ratio (FCR) for farmers using these feeds was 2:1 compared to FCRs of 1–1.5:1 for extruded feeds. In addition, feed ingredients and finished feeds are often badly handled and stored at feed mills, especially in state-owned mills and small privately-owned mills, while there is insufficient quality control inspection by government authorities, especially in private feed mills.
3. Seasonal production cycle. All feed mills work for only 6–7 months per year because demand from farms is seasonal, while permanent employees are paid for the whole year. This reduces the profit margins of mill owners and results in a preference for temporary rather than permanent employment. About 4000–5000 employees and workers are engaged in the fish feed industry, most of whom only work for 6–7 months per year.
4. Limited access to credit. Public fish feed mills find it difficult to offer credit to fish farmers so they sell most of their production through traders/retailers who can offer this service. Even in private sector mills where most farmers are offered credit terms, the feeds cost more and farmers risk being supplied with poor quality feeds.
5. Limited access to training. Most feed mills and fish farmers do not receive capacity building or other extension services. Without basic training, feed mills cannot make high quality feeds and farmers will use feed inappropriately leading to feed wastage and poor feed efficiency.

#### 3.9.2. Suggested actions

**3.9.2.1. Reduce dependence on expensive feed ingredients.** Many feed millers suggested that the government must intervene by applying strict regulations of imports and price controls to break up, or at least reduce, the monopoly that the private sector operators have over the importation of feed ingredients. Some also suggested that the government should import feed ingredients to make sure that the private sector does not control the market. Reduced import tariffs would also be a way of reducing feed ingredient prices. However, it seems unlikely that these actions could be implemented as they would have to apply across the entire animal feed industry. It may be more realistic for the authorities to introduce measures to encourage opportunities for local production of feed ingredients which would generate further employment at the base of the supply chain, but this would have to be weighed against the increased demand for land and irrigation water that would be needed for production of raw materials such as soyabean. In a water deficient country like Egypt, it may be more efficient to continue to import raw materials.

Alternative feed raw materials could make a useful contribution towards reducing costs but will require further research. Potential candidates include algal meals, single cell protein, insect protein, animal

and fish by-products, food processing by-products and nutrient-rich forages. However, the large scale of the Egyptian aquaculture industry means that very significant quantities would be required in order to make an impact.

**3.9.2.2. Improve capacity for production of high quality feeds.** Quality control and inspection procedures need to be put in place to improve feed quality. Inspection should include regular testing of feed ingredients and finished feeds, not just proximate analysis but also for contaminants such as mycotoxins. More feed mills should operate their own analytical labs so they can screen ingredients and verify that finished feeds meet expected specifications. Inspection of feed producers, suppliers and ingredient importers is necessary to assure that they comply with the international quality control standards, such as Hazard Analysis and Critical Control Points (HACCP) and the Code of Practice for Good Animal Feeding (FAO, 1998).

Extruded feeds are preferred by many Egyptian fish farmers because they are more efficient (in feed conversion terms) than conventionally pelleted feeds. However, they are much more expensive as the capital and operating costs of an extrusion processing line are higher than for conventional mills. Another reason why extruded feeds are preferred by some fish farmers is that feed management is easier with floating pellets than with sinking feeds. A major problem with many conventional mills in Egypt is that they use old, poorly maintained equipment and do not observe best practices through-out their handling, processing and storage lines. The result is poor quality feeds that will have clear impacts on fish growth and the profitability of fish farmers. Many of these deficiencies could be solved through training, whereas others will require new investment in equipment.

**3.9.2.3. Reduce seasonal variations in production.** The seasonal nature of aquaculture production systems in Egypt means that there is much higher demand for feeds in summer and autumn than in winter and spring. Although feed mills are operating at full capacity for half the year they stand idle at other times but this does not mean that there is spare capacity. As fish farm production continues to grow the peak feed requirement and employment opportunities will also grow, for both full-time and seasonal staff.

There are potential strategies to smooth out feed production through the year, thereby increasing the ratio of permanent to seasonal workers. One option would be to produce more feeds in the off-season and store finished feeds in temperature controlled stores for sale in the peak season. However, prolonged feed storage is undesirable and is likely to be more expensive than just increasing peak capacity of existing feed mills. There may be opportunities to improve the efficiency of feed mills, particularly in inefficient public sector mills, through training and rationalization. There may also be opportunities to extend the feed processing season by supplying export markets. Egyptian feeds appear to be competitive with international feed prices. As aquaculture is set to grow in other parts of Africa, Egyptian feed mills could target new markets.

**3.9.2.4. Improve access to credit.** Most Egyptian aquaculture businesses have a seasonal production pattern requiring significant investments in feeds over a six to eight month growing period before fish can be sold at the end of the year. The majority of fish farms are operated in leased ponds (which cannot be used as collateral) and many (perhaps 60%) are also unlicensed making it difficult for them to borrow money from formal sources such as banks to fund feed purchases. This forces them to depend on credit from feed mills, feed traders (in the case of farmers buying from government-owned mills) and sometimes wholesalers who will buy their fish at harvest. These informal credit relationships have allowed Egypt's aquaculture industry to grow, particularly for small-scale enterprises, but bringing in a more formal credit system will be difficult. Fish farms need to be licensed, they need better tenure over their land (most only have 3–5

year leases) and/or water, they need to have bankable collateral beyond the stock of fish in their ponds and commercial banks need to learn about how aquaculture works. There will be little progress on any of these issues unless fish farmers can organize themselves more effectively to fight their case.

**3.9.2.5. Improve access to training.** Egypt's aquaculture feed sector has expanded rapidly over the last few decades to meet growing demand from aquaculture producers. As this study has shown, there are many new feed mills, with a wide range of quality standards, from internationally recognized feed brands to farm-made feeds. While experienced operators and larger mills usually have in-house support for capacity building, smaller mills will not. Training will be required on sourcing quality materials, feed formulation, feed processing, equipment maintenance, marketing and business management in order to produce the high quality feeds expected by their customers. Meanwhile producers need training in feed storage, feeding systems and feed management to improve the efficiency of feed use.

**3.9.2.6. Strengthen the legal and policy environment.** While there are Ministerial Resolutions governing animal feeds, there are significant weaknesses in the legal framework and its application and enforcement in the aquaculture feed sector. These should include registration and regular inspections of business in the feed production sector as well as setting and enforcing quality standards. This could involve a partnership approach between a quality-focused feed industry organization and the regulatory authorities.

#### 4. Conclusion

This study demonstrated that Egyptian aquafeed value-chain is relatively simple, including only four main stakeholder groups; feed input suppliers, aquafeed producers, aquafeed marketers/traders and fish farmers. This sub-sector is not labour-intensive, nevertheless it employs 4,000-5,000 people in an industry where demand is growing due to expansion of the fish farming sector.

There are a number of opportunities that feed manufacturers should examine in order to improve the performance of the sector. The main opportunity is to improve the efficiency of feed mills, particularly the public sector mills, through training and rationalisation. There may also be opportunities to extend the feed processing season by supplying export markets as Egyptian fish feeds appear to be competitive with international feed prices, especially in Africa.

However, the aquafeed sector in Egypt faces a number of challenges that threaten its performance and sustainability. The biggest threat is the continuous increase in the prices of feed ingredients and processed feeds, especially when compared to static or, in real terms, declining fish prices. Other constraints include the seasonal production cycle, a lack of quality control and inspection, the out-dated equipment used in many mills, limited access to training and credit, and a poor legal and policy environment.

Appropriate interventions will be needed by the key stakeholders, who need to become better organized and represented, perhaps through forming a Producer Organization. The government should also support the sub-sector through improving the policy regulatory environment. Capacity building training is needed in many feed mills to improve their ability to produce high quality feeds. Meanwhile fish farmers need training in feed storage, feeding systems and feed management to improve the efficiency of feed use. Some of these issues are already being addressed by Best Management Practice training for fish farmers under the IEIDEAS project, while one of the working groups of the Egyptian Aquaculture Innovation Platform organised by Worldfish plans to develop training programmes for feed mill operators and test new fish feed technologies. These will help to improve the efficiency and profitability of the aquaculture sector ensuring that it continues to provide nutritional benefits to Egyptian consumers.

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