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Fish Production Economics Under Semi-Intensive Aquaculture Systems in Kafr- Elshiekh Governorate

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ABSTRACT

Aquaculture is a key solution to bridging the fish supply gap. Given its significance, this study focused on aquaculture farms in Kafr El-Sheikh Governorate, which is a leading region in Egypt in terms of total fish production. The governorate plays a particularly important role in Egypt's aquaculture sector, especially from an economic standpoint. In the study area, polyculture earthen ponds operated under semi-intensive systems were primarily used to produce monocultures of tilapia. Statistical analysis, including the chi-square (χ^2) test, was employed to assess the socio-economic characteristics of the producers. An analytical approach was also used to evaluate farm-level profitability. The study revealed a significant effect of employment on aquaculture participation ($P < 0.001$), with 55.4% of producers working exclusively in fish farming. Experience also had a significant impact ($P < 0.05$), with 47% of producers having more than 30 years of experience in the field. The Benefit-Cost Ratio (BCR) was calculated at 1.80 LE/kg. Total profit per feddan accounted for 44% of the overall return, while profit per ton represented 7%. Feed constituted the largest share of total costs at 62.5%. The Feed Conversion Ratio (FCR) was recorded at 1.23, indicating a growth rate deficiency, as fish size increased from an initial 10 to 275g by the end of the production cycle. These findings highlight the need for experts to develop alternative feed options that reduce operational costs while ensuring food safety. Additionally, a strategic approach to securing freshwater resources is necessary, particularly in light of declining fry quality and high mortality rates. The government should implement legislative measures to stabilize prices, enhance market infrastructure, and provide reliable marketing information to stakeholders. It is also essential to engage producers with relevant entities to strengthen extension services, training, and support, thereby ensuring the sustainability of the aquaculture sector. To maximize farm-level returns and contribute more significantly to Gross Domestic Product (GDP), intensive aquaculture systems should be adopted more widely across Egypt.

INTRODUCTION

Fish production plays an important role in providing per capita animal protein, especially given the high cost of other protein sources like red meat and poultry. The growing demand for fish, driven by a rapidly increasing population, highlights the need to preserve natural fisheries and lakes. Aquaculture represents a sustainable solution that addresses production constraints and helps bridge the gap between fish supply and demand. Between 2000 and 2020, aquaculture's contribution to global fish production rose from 25.7% to 49.2%. It is projected to supply 62% of the global fish demand by 2030 **(FAO, 2016)**. In Egypt, aquaculture production grew from 24,000 tons in 1992 to 1,576,189 tons in 2021 **(FAO, 2023)**. Approximately 80.5% of the nation's fish requirements were met through Egypt’s aquaculture industry **(GAFRD, 2019)**.

The cultivation of the Nile tilapia has driven the development of aquaculture hatcheries, which operate under three main systems: hapa-based in earthen ponds (hapa), hapa-based in greenhouse tunnels (greenhouse), and concrete tanks within greenhouses with water heating (heated greenhouse) **(Nasr Allah *et al.*, 2014)**. In Kafr El-Sheikh Governorate, the number of tilapia hatcheries reached 300 by the year 2000. Among these, 108 were licensed private hatcheries, while more than 500 were unlicensed **(LFRPDA, 2024)**. The average hatchery produces around 10 million fry annually, which are primarily sold as fry rather than fingerlings.

Fish farming in Egypt is classified into three main systems. Extensive systems are typically located in earthen ponds along the Nile River and are used for rearing fry and fingerlings for lake restocking, including grass carp. These systems are characterized by low inputs and limited outputs. Semi-intensive systems, which account for over than 85% of the total aquaculture production, are preferred by both small-scale and large commercial farms. Most of these farms are located in the northern and eastern Delta regions and use brackish and freshwater resources. **El Sayed (2007)** reported that fish produced under semi-intensive systems are largely cultivated in ponds in the northern Delta and the Maryut salt valley. Stocking density and infrastructure vary among farms, with financial inputs directed toward fish seed, low-grade feed, and labor costs.

Intensive systems utilize concrete ponds, tanks, greenhouses, and cages, and rely on high stocking densities, requiring significant capital investment. Feed, which represents 40 to 60% of total production costs, is a major expense. High output from intensive systems can be achieved through effective ventilation, strategic feed supplementation, and improved pond management **(El Gayar, 2003)**.

Despite the growth of aquaculture, the industry faces challenges, particularly related to water quality. The reliance on agricultural drainage water often leads to poor productivity and the accumulation of pollutants, which can affect fish safety and limit trade potential. Kafr El-Sheikh Governorate was selected as the study site due to its leadership in aquaculture; it ranks first nationwide in total fish production, contributing 776 thousand tons (38.8%), and third in total aquaculture production **(CAPMAS, 2021)**.

The aim of the present study was to evaluate semi-intensive aquaculture systems in Kafr El-Sheikh Governorate from an economic perspective. Using a farm budget approach, the study assesses profitability by comparing household total income with total production costs.

MATERIALS AND METHODS

The study was carried out at aquaculture farms in "Motobs" and "El Riad" districts of Kafr- Elshiekh Governorate (Fig. 1).

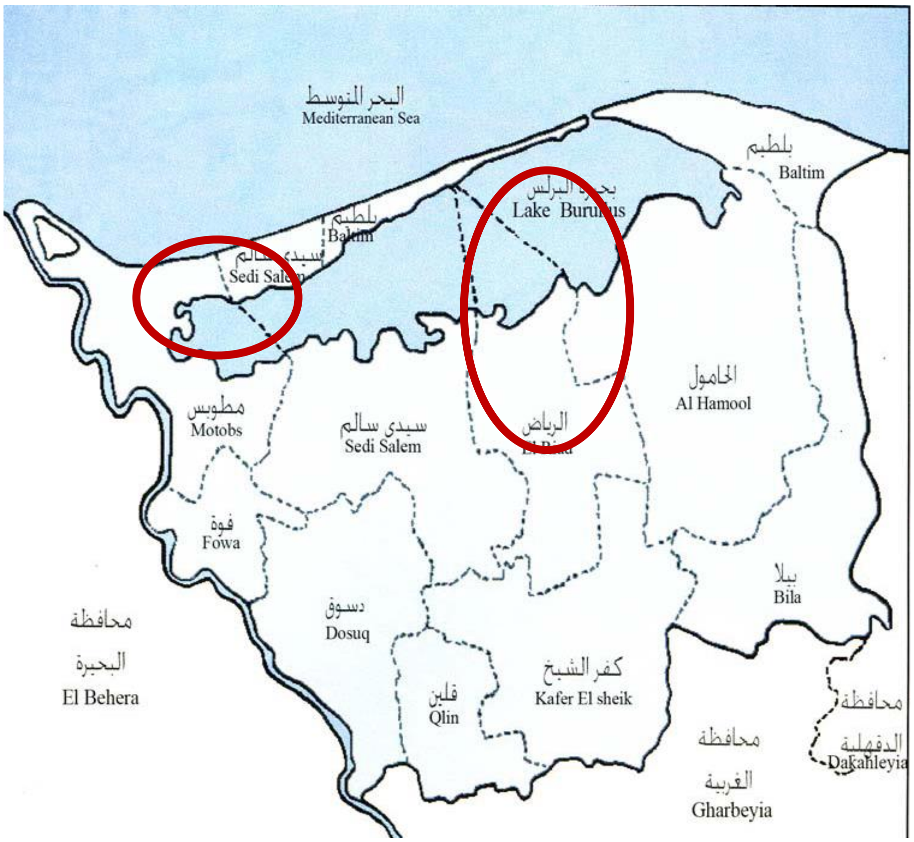

Fig. 1. Study area: "Motobs" and "El Riad" districts of Kafr- Elshiekh Governorate

Polyculture, derived from semi-intensive systems using shallow ponds, was practiced in the study area, although these systems primarily produced a monoculture of Tilapia (Fig. 2). Tilapia is the most commonly farmed fish species in Egypt, contributing 768,752 tons with a total value of 900,000 USD in 2013 **(Rothuis *et al.*, 2013)**.

A: Earthen ponds **B:** The Nile tilapia

Fig. 2. Semi- intensive aquaculture systems using earthen ponds

2. Questionnaire

2.1. Socio- economic characteristics

To assess the components of the production systems, a face-to-face interview strategy was conducted with 83 fish producers—50 from the El Riad district and 33 from the Motobas district. A structured questionnaire was designed to collect information on the producers’ gender, age, experience, education level, additional occupations, and financial status. This data was used to evaluate its impact on farm yield and, subsequently, household income.

2.2. Farm inputs

Farm inputs were expressed as production costs, including both fixed and variable costs. Data were estimated in Egyptian Pounds (LE) per feddan per production period.

2.3. Economic parameters

Total profit at the farm level was calculated as the difference between total income (LE/feddan) and total costs (LE/feddan). The Benefit-Cost Ratio (BCR) was assessed by dividing the sale price of one kilogram of fish (LE) by the total cost of producing one kilogram of fish (LE).

3. Data analysis

Microsoft Excel was used to conduct descriptive analysis, including the calculation of means for revenues, total costs, and the percentage of constraints faced by producers. Statistical analysis included the Chi-square (χ^2) test, following the procedure outlined by **Snedecor and Cochran (1993)**, to examine the effect of socio-economic traits (X_1 = gender, X_2 = age, X_3 = experience, X_4 = other job, X_5 = education level, X_6 = access to credit) on the distribution of respondents across three producer groups: G_1 = small producers, G_2 = medium producers, and G_3 = large producers, as follows:

$Y_{ij} = \mu + X_i + G_j + e_{ij}$ where,
Y_{ij}: is the percentage of respondents,
μ: is the overall mean,
X_i: the fixed effect of socio-economic traits,
G_j: the fixed effect of respondents` group,
e_{ij}: is the random error assumed to be NID $(0, \sigma e)$.
4. Supply and value chains

Marketing channels was mapped – from producer to consumer- to deduce obstacles faced selling and purchasing fish produced. Market price was determined by the wholesalers who explained a key role of the value chains concerning benefits along with the included stakeholders. According to **FAO (2010)**, regulations were needed to identify the origin of fish whether they are farmed or captured fish at the retailers' level.

RESULTS AND DISCUSSION

1. Respondents' characteristics

In Table (1), the socio-economic characteristics of the producers are presented. Producers were classified into three groups based on farm area: G_1 – small producers (less than 10 feddans), G_2 – medium producers (11 to 20 feddans), and G_3 – large producers (more than 20 feddans).

A significant effect ($P < 0.001$) was observed for employment status, where 55.4% of producers worked exclusively in fish farming. Meanwhile, 44.6% relied on an additional job and used that income to support aquaculture activities. Moreover, experience had a significant effect ($P < 0.05$), with 47% of producers having more than 30 years of experience in the field. **Das *et al.* (2018)** reported that fish farming often began without prioritizing training objectives, and most producers in this study indicated that their initial involvement in fish farming was influenced by social media.

The sample consisted of 95.2% male and only 4.8% female producers. Despite the low participation rate, women have demonstrated their value in various farming operations, especially in selling and purchasing products **(UN Women, 2018)**.

In terms of age, 59% of producers were over 40 years old. This older demographic may help explain the limited adoption of modern technologies in fish farming. Regarding education, producers showed a generally adequate level of educational attainment. High school graduates represented the highest proportion at 41%, while college graduates made up a percentage of 12. **Rashid and Ashab (2022)** noted that 60% of producers had completed graduation-level education. In contrast, **Siddiqua *et al.* (2019)** found that only 3% of fish farmers had completed graduate studies.

In terms of financing, 85.5% of producers used their own cash to cover farm requirements. This finding is consistent with **Al Asif *et al.* (2017)**, who reported that none of the respondents in their study accessed bank loans. Producers typically finance farm operations and sanitation efforts independently.

Table 1. Producers`socio economic characteristics

Variable	G1		G2		G3		Total		Test	
	N	%	N	%	N	%	N	%	$\chi 2$	Pro.
Gender										
Male	22	26.5	45	54,2	12	14.4	79	95.2	**4.11**	**0.1275**
Female	3	3.6	1	1.2	0	0	4	4.8		
Age (year)										
From 20 to 30	8	9.5	5	6	2	2.4	15	18.1	**4.96**	**0.2907**
From 31 to 40	5	6	11	13.3	3	3.6	19	22.9		
> 40	12	14.4	30	36.2	7	8.4	49	59		
Experience (year)										
From 5 to 10	4	4.8	3	3.6	0	0	7	8.4	**14.69**	**0.0228***
From 11 to 20	4	4.8	8	9.6	0	0	12	14.5		
From 21 to 30	10	12	14	16.9	1	1.2	25	30.1		
>30	7	8.4	21	25.3	11	13.3	39	47		
Other job										
Yes	19	22.9	15	18.1	3	3.6	37	44.6	**14.52**	**0.0007*****
No	6	7.2	31	37.4	9	10.8	46	55.4		
Education level										
Illiteracy	3	3.6	3	3.6	0	0	6	7.2	**11.64**	**0.1679**
Primary	3	3.6	10	12.1	0	0	13	15.7		
Secondary	5	6	12	14.5	3	3.6	20	24.1		
High school	11	13.2	14	16.9	9	10.8	34	41		
College	3	3.6	7	8.4	0	0	10	12		
Access to credit										
Yes	3	3.6	7	8.4	2	2.4	12	14.5	**0.19**	**0.9090**
No	22	26.5	39	47	10	12	71	85.5		

***=P< 0.001, and *=P< 0.05.

2. Farm inputs

Farm inputs were categorized into fixed and variable costs (Table 2). Among these, feed represented the highest share of total costs, accounting for 62.5%. Feed prices have risen sharply due to recent economic measures, as most feed components are imported. The reduced availability, irregular supply, and poor quality of fish feed have negatively impacted fish growth performance. As a result, alternative protein sources have emerged as a potential solution.

The use of plant- or animal-based protein as partial or full replacements for fish meal has been discussed in many studies. Technological advancements have played a significant role in mitigating the risks associated with high feed prices and overfishing **(Abdel-Warith *et al.*, 2016)**. **El Sayed (2014)** reported that fish farmers were able to reduce feed costs by 10% to 15% when they purchased feed ingredients themselves, formulated their own rations, and rented a feed mill for manufacturing.

Nile Tilapia fry have been produced by private freshwater hatcheries since the early 1990s to meet the increasing demand from fish farms. According to **GAFRD (2020)**, the annual production of fish fry increased from 538 million units in 2011 to 721 million units in 2020. Many hatcheries focus on producing male fingerlings with controlled sex characteristics. Seasonality has been identified as a challenge in aquaculture, requiring adaptation strategies to manage temperature fluctuations, which affect the ideal conditions for fish growth and reproduction, and thus the consistency of fish seed supply.

FAO (2014) reported that 580,000 Egyptians were employed in aquaculture, representing a higher percentage than all other African countries combined. The rapid growth of the aquaculture sector has created numerous job opportunities, supported by the emergence of related industries and financial services. **MacFadyen *et al.* (2011)** found that labor accounted for 8% of total operational costs, while fuel made up approximately 3% of total production costs.

Future research should explore the optimal use of renewable fertilizers and energy sources to enhance profitability and minimize the loss of valuable production inputs.

Table 2. Total costs: fixed and variable costs of aquaculture farms

Variable	**Total costs LE*/ Feddan / Period****	
	Unit	**Price**
Fixed costs		
- Feddan rent / year: one feddan = approximately 4200m^3	1	18000
- Fixed labor: appointed as farm guard salaried 4000 LE/ month	1	36000
- Fuel: amounted 675 LE per one package (55 liter)	6	4050
- Labor housing: rent per LE per year	1	30000
		88050

Total		
Variable costs		
- Fish feed/ tons: sales at 23 LE per kg	8	184000
- Fish seed/ feddan: estimated 1000 at 450 LE	25000	11250
- Labor: employed in harvesting season at 200 LE for one labor in 3 days	3	1800
- Chemical (fertilizer)/ feddan: amounted 700 LE for the package (59 kg)	9	6300
- Equipment maintenance: water pump	1	3000
Total		**206350**
Total costs		**294400**

*LE: Egyptian pound = 1/ 45 USD
** Production period= 9 months

3. Productivity

The Benefit-Cost Ratio (BCR) was estimated in terms of Egyptian Pounds (LE) per kilogram of fish produced (Table 3). A relatively low BCR value of 1.80 was recorded, primarily due to a decline in the sale price, which was determined to be 83 LE/kg in comparison to total production costs. **Rashid and Ashab (2022)** reported a lower BCR of 0.55 for Nile Tilapia, attributing this to the high cost of feed and fingerlings, as well as the quality of both feed and fish seed.

While the profit margin per feddan was recorded at 44%, the profit margin per ton of fish was only 7%. Total production per feddan averaged 6.5 tons, with a stocking rate of 5.54 fish/m³ (equivalent to 1.52kg/ m³). The Feed Conversion Ratio (FCR)—calculated as the ratio between feed intake (tons per feddan) and fish production (tons per feddan)—was 1.23. This indicates a relatively low growth rate, as the average fish size increased from 10 g at the beginning of the production period to 275g at harvest.

Boateng *et al.* (2013) found that production operational costs could be reduced by up to 30% when farmers apply effective feeding techniques and utilize biofloc systems. Producer skill level is therefore considered a key factor in enhancing system profitability. Another factor affecting net profit lies in value chain dynamics. When traders collect fish directly from farms, transportation costs are reduced, and traders' commissions are lower compared to fish delivered through intermediaries. Total farm production and fish size strongly influence the sale price—lower production levels typically result in lower sale prices.

Nasr Allah *et al.* (2012) reported that Kafr El-Sheikh had the lowest net profit per ton at just 503 LE. The authors attributed this to low stocking rates, poor fish seed quality, and rising operational costs. Perceived increases in operational costs have been largely dominated by feed expenses, which have surged by 200 to 250% over the past 6 to 7 years. Consequently, declining profitability poses a serious threat to the sustainability of the fish farming sector.

Table 3. Total income, total profit and BCR of the studied production systems

Variable	Total production/ Feddan/ Period
Production traits	
- Total production/ ton	6.5
- Average stocking rate	
○ Number of fish (m^3)	5.54
○ Kg fish (m^3)	1.52
- Average size when stocking (g)	10
- Average size when harvesting (g)	275
Feed Conversion Ratio (FCR)	1.23
Profitability	
- Average sale price LE/ feddan	531, 200
- Average profit LE/ feddan	236,800
- Average profit LE/ ton	37000
- % of profit/ feddan*	44%
- % of profit/ ton**	7%
- Benefit Cost Ratio (BCR) LE/ kg	1.80

*Divided average profit/ feddan by average sale price/ feddan.
**Divided average profit/ ton by average sale price/ feddan.

4. Supply and value chains

4.1. Marketing channels

After sorting and collecting, fish are either transported to the wholesale market or directly delivered to wholesalers who have prearranged financial agreements for delivery to their market stores. Another common marketing route involves intermediaries who distribute fish boxes to traders in exchange for an agreed-upon commission. These intermediaries then transport the fish to market locations where wholesalers interact with retailers, both within and outside the markets.

In the final phase of the marketing process, fish are delivered to government-run fish outlets and ultimately reach consumers. Fig. (3) illustrates the marketing channels of the fish produced in the study area.

Wholesalers often provide financial support to producers, helping to cover farm operation expenses. This highlights the significant influence wholesalers have within the value chain. Their gross margins range from 3 to 6%, depending on the sales commission paid by the producers. The commission typically increases to 6% when wholesalers collect fish directly at the farm gate, as transportation and ice costs are added.

Marketing dynamics are shaped by daily or seasonal price fluctuations, which are considered one of the main factors influencing value chain efficiency. According to **MacFadyen *et al.* (2012)**, value chain analysis in aquaculture has largely overlooked technical aspects, resulting in the sector's underutilization of value chain strategies.

To enhance both financial and social outcomes, value chain analysis must identify the critical factors that affect producers' final returns. It should also support innovations and strategic actions that improve profitability and contribute to broader economic indicators such as Gross Domestic Product (GDP).

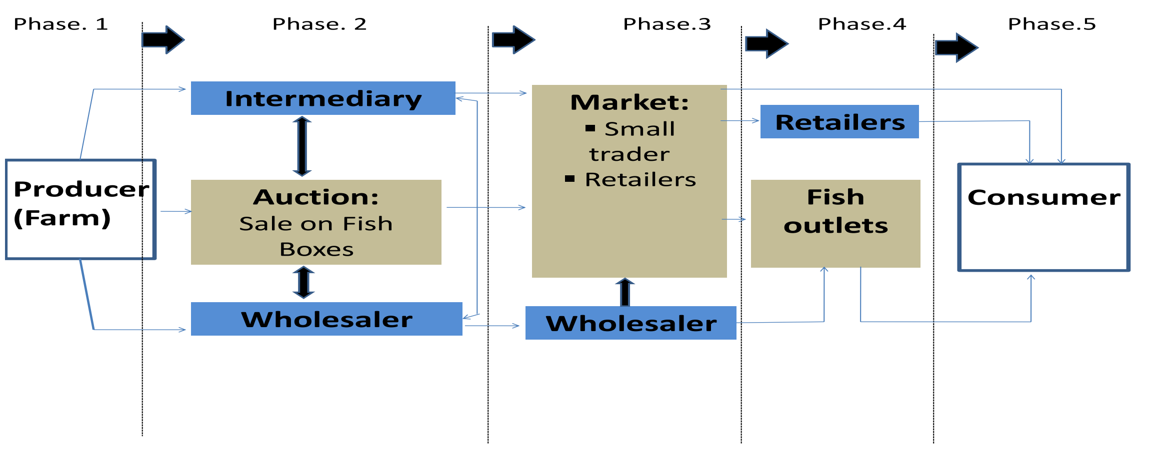

Fig. 3. Aquaculture supply and value chains

4.2. Constrains

As shown in Fig. (4), 85% of producers rely on self-financing to meet their operational requirements. This is largely due to a lack of confidence in bank financing and concerns about the risks of nonpayment associated with loan-based funding. The role of non-governmental organizations (NGOs) is seen as essential in supporting producers—either through direct financial assistance or the provision of production inputs.

Producers acknowledged weaknesses in the services provided by the government, particularly regarding technical guidance and training. Farm sanitation, in particular, requires more involvement from relevant authorities through on-site visits, mobile service convoys, and face-to-face interactions to better understand and address producer challenges. As a result of these service gaps, most producers continue to rely on conventional breeding methods, with little awareness or adoption of modern technologies or practices.

Since fish production is highly seasonal, income is concentrated around the harvesting period. This limited return window significantly affects producers, especially those who do not have alternative sources of income. Furthermore, the release of large volumes of fish into the market during harvest season typically leads to a drop in sale prices, reducing producer-level profitability.

Producers expressed concerns about the lack of adequate market infrastructure, unstable fish prices, and limited access to marketing information. Due to sharp price fluctuations, wholesalers often control the pricing, making it difficult for producers to accurately assess profits over the production cycle. To address these issues, government intervention is needed in the form of legislation that prevents price manipulation by traders and ensures transparent dissemination of market information. Improvements in market infrastructure are also necessary to stabilize the sector.

GAFRD (2005) outlined a national policy for developing aquaculture in Egypt, focusing on increasing returns through "environmentally compatible systems," maintaining a per capita fish production of no less than 16.5 kg annually, diversifying fish product sources in line with international standards and promoting the growth of marine aquaculture.

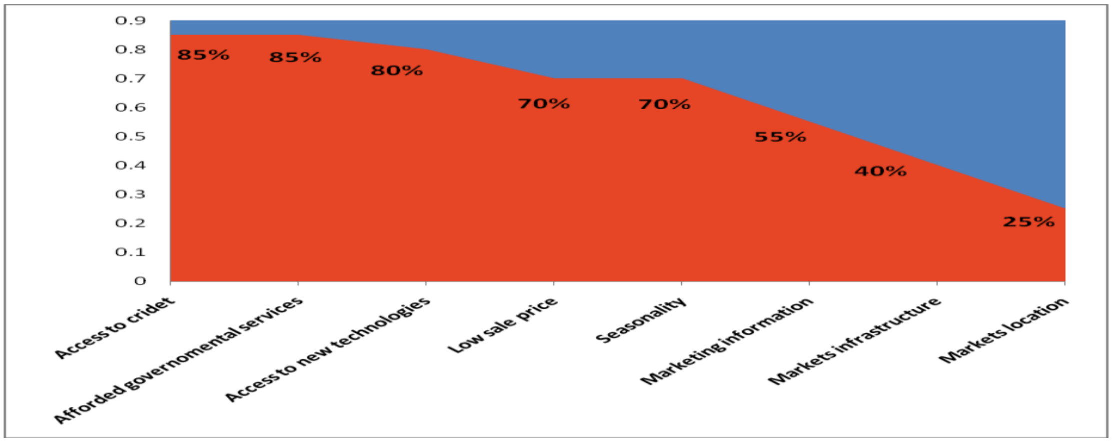

Fig. 4. % Market and trading- related constrains

CONCLUSION

The results of the study indicate that Egypt's aquaculture sector must shift its focus toward intensive production systems. Capital investments should be directed toward the development and expansion of intensive aquaculture systems to achieve higher returns at the farm level and to contribute more significantly to the national Gross Domestic Product (GDP).

Among the critical inputs in fish production, water is especially important. Water scarcity has played a major role in production deficiencies and requires strategic intervention by authorities to ensure a reliable supply of freshwater. Additionally, poor-quality fish seed has been identified as a major factor contributing to high mortality rates during the production cycle.

A significant increase in feed prices—linked to current economic measures and fluctuations in currency exchange rates—has further impacted production costs, given that most feed ingredients are imported. This highlights the urgent need for experts to develop alternative feed sources, with careful consideration of biosafety and the health implications of the ingredients used.

The government must implement legislation aimed at stabilizing fish prices and improving market infrastructure. Furthermore, efforts should be made to ensure that accurate and timely marketing information is accessible to stakeholders across the value chain. Government agencies should also be directed to confront the real challenges facing aquaculture by identifying and addressing key obstacles, and by engaging producers with relevant institutions to enhance the delivery of technical guidance, training, and services. These measures are essential to ensure the sustainability and growth of Egypt's aquaculture industry.

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