مجلة البحوث المالية والتجارية
المجلد (24) – العدد الأول – يناير 2023

Fish Production and Profitability in Emerging Markets: Evidence from Egypt

Dr. Ahmed Elrawas
College of Management and Technology,
Arab Academy for Science, Technology and Maritime Transport (AASTMT).
ahmedelrawas@aast.edu

Dr.Osama Wagdi
Faculty of Management, Economics and Business Technology,
Egyptian Russian University (ERU).
osamawagdi_ta@yahoo.com

Dr. Sharihan Mohamed Aly
College of Management and Technology,
Arab Academy for Science, Technology and Maritime Transport (AASTMT).
dr.sharihanmohamed@aast.edu

تاريخ الإرسال	2023-01-13
تاريخ القبول	2023-02-07
رابط المجلة:	https://jsst.journals.ekb.eg/

Abstract

This study investigated fish production in Egypt. Under Fish Macroeconomics in Egypt, fish production has expanded to about 418,600 tonnes in 2020 from natural fisheries. But fish farming reached 1.59 million tonnes in 2020 (compared to 1.64 million tonnes in 2019, decreasing by 3%). Based on the fish microeconomics production function in fish farming, the independent variables can be arranged according to the relative importance of their impact on the fish mixture (mullet and tilapia). The variable feed quantity occupies the first place, followed by organic fertilisation, the number of fingerlings, the number of employees, the duration of the production cycle, the amount of oil and fuel, and finally the farm manager's experience. Based on the cost structure, fixed and variable expenses made up 13.2% and 86.8% of total operating costs, respectively. Based on the fish microeconomics profitability function, the findings revealed how successfully tilapia and mullet fish were produced per acre in sample farms in Fayoum Governorate: The ratio of total revenues to total expenses was roughly 1.9. The quantitative break-even threshold was 0.34, which means the production process is in the farm owners' interest. Therefore, fish farm profitability analysis is favourable. Encourage farm owners to maintain and grow production initiatives and handle producer difficulties.

Keywords:

Fish Production; Fish Farming; Aquaculture; Fish Farm; Egypt

1. Introduction

The world population is rising, and technological measures must be made to provide food security, particularly for the essential animal protein required by the expanding human population. Several initiatives are devoted to fish production to meet the need. Aquatic ecosystems have been studied by establishing fish production facilities (Aïzonou et al., 2021). Fish is an important source of animal protein that humans need to maintain their health. It contains fatty acids necessary to protect humans from heart and circulatory diseases. Fish protein is characterized by ease of digestion, absorption, and representation compared to the protein found in meat and poultry (Yue et al, 2020).

Egypt suffers from a deficit in the production of animal protein and a low per capita share of animal protein compared to the global average, as the average per capita share of animal protein in the world is about 27.5 kg per year, while Egypt hasn't reached half of this rate (Abdelbaki, 2021). Due to problems that plague the expansion of meat and poultry production, such as the limited agricultural area and the intensification of competition for major crops such as wheat and fodder crops, and the deficit in the production of concentrated feed, most of the requirements of animal production are imported from around the world (Guyomard et al., 2021). The sources of fish production in Egypt vary between natural fisheries and fish farms, with an average production of about 380 thousand tonnes (20% of the total production), which represents about 80% of the total fish production. This proves that Egypt's fish farms are one of the most important ways to get fish (Hassan and Elbahy, 2022).

So, the development of fish production is one of the pillars of developing protein sources in Egypt. Within a national plan adopted by the Egyptian government to raise fish production to 3 MMT by 2025, fish production increased by 17.64 percent, from 1.7 million metric tons (MMT) in 2016 to 2 MMT in 2020. Aquaculture's share increased to 1.62 MMT in 2020 compared to 1.37 MMT in 2016 (about 81% of total fish production). The total fish production in 2021 reached 2.2 MMT (aquaculture contributed 1.7 MMT).

It should be noted that Egypt is the 7th largest fish producer in the world due to its distinguished geographical location, where fish production has achieved a great boom during the past two decades, as the average fish production exceeded 2 million tonnes (Feidi, 2018). The marketing of fish is inseparable from the production activity because fish producers aim to speed their marketing. As the prices of fish are directly proportional to the degree of freshness of the fish, it is characterized by rapid deterioration (Eltholth et al., 2018).

This study analyses the aquaculture systems of mainly small-scale fish farmers in Egypt as one of the emerging markets like Bangladesh and Myanmar, focusing on assessing the economic and productivity performance of aquaculture systems with tilapia as the dominant species in Egypt. This is based on an analysis of the economics of fish farming in Fayoum Governorate. Therefore, the study relied mainly on the descriptive analysis method, which depends on describing the data, linking them logically, and extracting indicators. But before the statistical analysis, the study includes a literature review and a study design.

2. Literature Review

Much literature dealt with the economics of aquaculture and fish farming. Such literature will be reviewed on two levels; the first is related to international experiences, and the second relates to the economics of fish farming and its obstacles in Egypt.

2.1 Studies on international experiences:

Mavraganis at. Al., (2020) found that the expansion of fish farming contributes to creating more opportunities and provides experience in deepening the use of chemicals, disinfectants, and anti-pollution methods, as this contributes to enhancing the economic value of fish farms and intensifying production methods, and this positively affects the sectors other agricultural. It recommended the use of some chemicals and the reliance on antibiotics necessary to rid marine organisms of diseases that hinder their reproduction.

In Asia; Iliyasu et al (2016) studied the bias-corrected technical efficiency of different culture systems and freshwater aquaculture species in Malaysia using Primer Data Sheet Analysis. It concluded that the age of farmers has a negative and statistically significant effect on technical efficiency. Although educational level and farm condition have a positive effect on technical competence, their statistical significance is not statistically significant.

Wang et al (2020) studied the Chinese experience in aquaculture, and concluded that China had established a relatively comprehensive system of aquaculture expansion under the leadership of the Ministry of Agriculture and Rural Affairs. The five-level state-owned extension bodies are the main bodies, and research institutions, universities, social

organizations, and water enterprises are important sectors. He emphasized that specialized extension programmes, exhibition areas, and technical advice were the three common models for expanding aquaculture.

Plamoottil and Kumar (2022) studied the prevailing trends in aquaculture and fish production in two of the largest Asian countries (China and India), as India, in recent years, recorded about 78% growth in fish production, while China recorded 50%. It concluded that there is a difference in the growth rates of the production of captured fisheries and aquaculture and that China has been more stable in the long run, while India has shown a clear relative volatility.

In Africa; Otieno (2019) studied the economic implications of pond-fish predation by piscivorous birds in small-scale aquaculture in Kenya have been studied. It concluded that urgent action through habitat management and capital support is a necessary step to reduce investment losses and maintain the local food supply while protecting wildlife.

Debebe and Bessie (2022) evaluated the trends of fish farming projects in Ethiopia and identified the obstacles facing aquaculture projects and ways to overcome them. It showed that 93% of fish farmers prefer earthen ponds for fish farms. It emphasized that the absence of fish farming techniques and the lack of good types of breeding and suitable fingerlings represent the main obstacles to fish farming. It suggested doing more research on extension services for people who work on fish farming projects. This would help to improve their skills and increase the wealth of fishing.

Avadí et al. (2022) studied the main challenges to developing aquaculture value chains in Zambia, comparing large-scale aquaculture pond systems with large cage-based pond systems. It was found that the value chain contributes to the promotion of economic development. One of the constraints to aquaculture development in Zambia is that of smallholders. It suggested more efforts to enhance the environmental sustainability of smallholder production systems while preserving the status of large producers.

Justin et al. (2022) studied aquaculture and aquaculture development trends in Malawi, focusing on the effects of different modes of feeding using pig manure on tilapia fish farms. It was concluded that the survival rates did not show statistical significance, and it was found that the presence of quantities of chlorophyll confirms the effectiveness of the integrated systems of aquaculture and agriculture combined.

In Europe; Ylmaz et al. (2022) examined the use of feed additives to prevent fish diseases in the Turkish aquaculture sector. It concluded that with the chemical treatment, the concentration of total ammonia, nitrite, and nitrogen in the microalgae with biofilm carriers decreased without any biological increase, and fish production improved by 13.3. It recommended the analysis of the microbial community, as the low conversion of organic nitrogen and nitrogen removal contribute to the uptake of most chemical compounds by algae.

Masi et al (2022) analysed the habits and preferences of consumers for fish products in Mediterranean countries in order to identify homogeneous and cross-sectional behaviours in the four countries under analysis in order to identify common marketing actions and factors. It found that fish stocks are under pressure and European consumers

focus at the same time, the aquaculture sector, which could present itself as a solution to the problems highlighted in this study, does not express its full potential because of many misconceptions that tarnish its image, in particular the better quality of wild fish and the freshness of farmed fish.

On the other side; Tsiaras et al. (2022) conducted experiments to simulate the production of fish farms to verify their ability to environmental suitability and to prove the effectiveness of different modelling systems as a framework for planning aquaculture in the eastern Mediterranean region, and they aimed to examine the fate of aquatic waste and evaluate the potential effects of different ecosystems on efficiency. Productivity of aquaculture systems. Calleja et al (2022) found that the productive efficiency of fish farms is related to the environmental conditions, as it monitored the percentage of the efficiency of the dispersal of marine litter. Changes in the structure of the food web from fish farm wastes were affected by an increase in the proportion of dinoflagellates as an indicator of eutrophication, in addition to some micro-plankton. It concluded that there is a high potential for fish farming projects as it showed a high degree of suitability for the environmental conditions of fish farming projects.

In Caribbean Region: Valderrama et al (2016) studied the challenges facing aquaculture in the Caribbean, it conducted a cost-benefit analysis in fisheries since 2010. It was concluded that the main factors affecting competitiveness are high electricity prices that are commonly found in the Colombian Caribbean and elsewhere in the region.

In Latin America: Valenti et al (2021) revealed the knowledge gap between growth and reproduction and its implications for productivity in Brazil. It found that the challenge for truly sustainable production systems to support a sustainable industry is to develop new technologies, including digital devices and simple disruptive innovations, to increase productivity and support the transition to a circular economy, bio-economy, and sustainability backed by science-based innovations and knowledge.

2.2 Studies focused on the local environment in Egypt:

Nobrega, et. al. (2020) found that fish breed and size, acclimatization temperatures, specific rearing practices, and the quality and quantity of dietary fat containment are of paramount importance when developing winter production techniques for Nile tilapia. Adoption of appropriate farming practices, maintenance of physiologically appropriate fish, and minimization of stress factors during the winter season are essential to the successful production of Nile tilapia in subtropical regions worldwide.

Zwirn (2002) examined the prospects for enhancing food security in Egypt through the fisheries sector, mitigating environmental consequences, and rationalising resource use. It concluded that inequality in access to capital, in addition to the repercussions of the political environment, is the greatest obstacle to the development of the fishing sector in Egypt. Munguti A, et.al (2022) studied the obstacles facing the development of fisheries and their impact on profitability. It found about 75% of the respondents achieved high profitability by selling the produce at the farms. The rate of interest to be returned was 85% in the study sample. In addition, there are many challenges facing

fish farming, such as the high prices of energy, feed, and medicine, and the lack of operating capital, which explains the high mortality rate. There were also marketing problems. It all affects profitability.

Soliman and Yacout (2016) argued that the fish farming sector in Egypt has witnessed a remarkable development in recent years with the increase in the number of fisheries all over the country. As a result, aquaculture represents a major option to overcome the imbalance between fish production and consumption in Egypt. Egypt's fishing wealth has grown and become more diverse because the government and private sector have put more money into the feed industry. Egypt is now the ninth largest fishing economy in the world and the first in Africa.

Shaalan et al., (2018) studied current practices in freshwater fish farming and the most important fish species produced in Egypt. It focused on the constraints facing sustainable development in the fish industry, as they varied between the availability of feed and seeds, production costs, labor, and lack of techniques, in addition to problems related to regulations and legislative frameworks.

Nasr-Allah et al., (2020) examined the challenges face the fishing industry and their relationship to sustainable development. The majority of these challenges were gender inequality, poverty, and unemployment. Since fish farming is a big part of the Egyptian economy. This is because aquaculture has a lot of job opportunities and has a lot of potential to help meet food security needs.

Adeleke et al. (2021) studied the development of aquaculture by comparing the cases of Egypt, Nigeria, and Uganda, where aquaculture represents a promising sector in these three countries. Economic value

is determined based on many factors, such as production tonnes and value (S), prevailing production systems, soil types, and aquatic organisms. It concluded that there are a number of common obstacles between the three countries, such as the environment and the adopted political frameworks. Ashour (2020) argued that despite the great potential in the marine life sector in Egypt, 95% of the fish production in Egypt comes from fresh water, which means that the aquaculture sector in Egypt is still in need of further development. It concluded that there are obstacles facing the fish farming sector in Egypt, such as the quality and quantity of algae in marine hatcheries, and there are other obstacles, such as the poor ability to provide food in an appropriate quantity and quality. However, it indicated that there are great growth opportunities in the aquaculture sector, such as the SMIAF project, which aims to develop an ideal model for sustainable aquaculture farms that provide efficient, environmentally friendly, and high-economic value seafood.

Abdel-Aziz et.al (2021) studied the effectiveness of fish farming on the national income. It verified the appropriateness of the conditions surrounding fish farming in Qena Governorate, southern Egypt. 25,000 were supported in a single-sex aquarium and fed specific species of fish with 25–30% protein. The treated water was used on a fish farm that was supplemented with natural fertilizers. After treatment, it was concluded that the fish farms succeeded in increasing the production value of the crops that were produced with fish, such as tomatoes and zucchini by 24.4% and 30.52%. It recommended the use of multiple systems for fish farming in the desert to ensure the diversity of fish and

vegetable products, as this contributes to reducing the amount of fertilisers used.

2.3 Studies focused on factors effecting on fish farming production:

Maina (2014) assessed the impact of social factors on fish farming in Kenya and assessed the impact of fish farming productivity efficiency in Kenya. Production factors were determined by the gender, age, and education level of respondents; they influence fish management activities, and aquaculture. This is reflected in production cycles and negatively affects profitability. It makes fish farming projects unsustainable.

Rahman (2017) assessed the profitability of fish production in aquaculture through data for 15 farms categorized into 3 fish groups. The production function analysis indicated the positive contribution of fingerling fish and fertilizers. The human labor rate has decreased significantly. It found a large degree of variance in aquaculture by means of regression equations, which confirms that fish farms have a high profit return. The factors of production in the equation may be determined on the basis of gross return, fingerling cost, feed cost, fertilizer cost, human labor cost, natural logarithm, and intercept. The study concluded that fish production from aquaculture is more profitable and environmentally friendly.

Deng (2020) reviewed and assessed the factors affecting fish production and marketing in Gambella. It revealed many factors that contribute to reduced production, such as inefficient fish production, poor access to transportation, poor post-harvest handling, and fishing

methods. It found that drying is the optimal method for post-harvest handling. The main constraints on fish productivity are low prices, high transportation costs, poor energy supply, insufficient institutional capacity, and limited resource allocation.

Wanja (2020) assessed the potential risks of fish mortality and fish farming management and their implications for productivity. It found that the most important factors affecting the sustainability of aquaculture are fish diseases. This necessitates various activities of fish farming management such as pond fertilization, high fish stocking density, elevated levels of nitrates, and high ammonia in fishponds.

Dorji (2022) assessed the impact of social and economic factors on fish production; it explored the impact of aquaculture projects and productivity on fish farming activities and studied the effect of productivity improvement on the probability of successful small-scale fish production. It concluded that improving productivity can be used as a policy tool to reduce the possibility of farmers' exiting aquaculture activities and increase overall production at the same time.

3) Study design

Despite the growth of fish farming activities, and economic development plans as a means to contribute to improving food security, fish farming projects face many problems that are reflected in their economies, this affects the continuation of these farms' activities, achieving their economic goals and development, and attracting new investors in this activity. Therefore, the study aimed to identify the economics of fish farming in Fayoum Governorate, Egypt, by studying the productive and economic efficiency of fish farms in Fayoum,

analyzing the value chain of private fish farms in the study sample, and identifying the factors associated with it from the beginning of production until the final consumption, and studying the most important problems they face, and how to confront.

Fig. 1: Administrative map of Fayoum governorate,

Fig. 2: Fayoum governorate at the map of Egypt

Therefore, the study relied mainly on quantitative analysis of data using statistical methods and standard economic methods appropriate for the economic evaluation of fish farms, through statistical methods, including averages, percentages, and the income statement. The general time trend equations in the growth and linear images were estimated, and the best ones were selected according to the statistical logic. Autoregressive Integrated Moving Average (ARIMA) predictive models were also used because they are dynamic models that take into account the variables of the model, which makes the analysis more accurate within the framework of the stable time series.

The study relied on published and unpublished data from various official bodies such as the Egyptian Ministry of Agriculture and Land Reclamation, and its affiliates, such as the economic affairs sector and public authorities for fisheries development, data from the Central Agency for Public Mobilization and Statistics, and the World Bank website for the period from 2010 to 2020. Analyzing this data to identify

the future growth rates of fish production and consumption in Egypt as predicted for 2030.

The study sample was selected through a stratified random sample of fish farms in Fayoum Governorate in Egypt through many regions (Ibshaway, Senoras, and Youssef Al-Siddiq). The relative importance of the number, area, and production of fish farms in Fayoum Governorate reached (53.24%, 29.17%, and 7.14% in the arrangement: 40 farms were selected as a sample for the study for the period from 2018 to 2021. They represent 18.5% of the total fish farms in Fayoum Governorate and were distributed according to the relative importance of the number of farms in each region, and 10 wholesalers representing 33% of the total number of wholesalers in Fayoum were selected. In addition to 20 retailers representing 20% of the total retail trade in the governorate.

4) Data Analysis

4.1 Fish Macroeconomics in Egypt:

4.1.1 Fish production in Egypt:

Fish production in Egypt is estimated at 2 million tons, increasing by an average of 1.6 million tonnes during 2010-2020. By estimating the equation of the general time trend for the quantity of local production of fish, it increased and took significant significance at 0.01 with an increasing annual growth rate of 5.1%, where (F) was estimated at 175.28, the value of the coefficient of determination (R2) was 0.96. It means that about 96% of the changes in the amount of local fish production are due to factors reflected in the element of time. The predictive values of the quantity of local fish production during 2023-

2030 ranged from 2.2 million tonnes (minimum) in 2023, to about 2.5 million tonnes (maximum) in 2030.

Fish production amounted to about 14.5 billion EGP in 2010, while the maximum reached about 61 billion EGP in 2020, comparing to 61,1 million EGP in 2019, increasing by 1.3%. the average reached about 30 billion EGP during the period (2010-2020). By estimating the equation of the general time trend for the development of the value of fish production, it increased at a statistical significance level of 0.01 with an increasing annual growth rate of about 16%, where the value of (F) reached about 160.64. The value of the coefficient of determination (R2) was about 0.95. This means that about 95% of the changes in the value of fish production are due to factors reflected in the element of time.

4.1.2 Fish production from natural fisheries:

The minimum quantity of fish production from capture fisheries amounted to about 335.6 thousand tonnes in 2016. The maximum amounted to about 418,6 thousand tons in 2020, compared to 397, in 2019 (increasing by 5.5%), the average reached to 363.8 thousand tonnes during the study period. Therefore, there is no significant significance to the equation of the development of fish production from capture fisheries. When the Autoregressive Integrated and Moving Average Model (ARIMA) was used to predict fish production from capture fisheries for the years 2023 to 2030, the values ranged from 379.4 thousand tons in 2023 to about 373 thousand tons in 2030.

4.1.3 Production from fish farming:

The minimum quantity of fish production from aquaculture amounted to about 919.6 thousand tonnes in 2010. It reached to 1.59

million tonnes in 2020 (comparing to 1.64 million tonnes in 2019, decreasing by 3%) the growth average is estimated by 1.23 million tonnes during the period (2010-2020). It was found that there was no significant sign of the evolution equation for fish production from culture. The predictive values of the amount of fish production from aquaculture in (2023-2030) ranged between 1.8 million tonnes in 2023 and 2 million tonnes in 2030.

4.1.4 Per capita fish:

The average per capita consumption of fish has increased annually, where the minimum reached about 19.7 kg/year in 2010, while the maximum reached about 25.38 kg in 2019, with an average of 21.3 kg (2010-2019). It is also evident that the predictive values of the average per capita consumption of fish annually for the period (2023-2030) ranged between 26.5 kg in 2023 and 28.5 kg in 2030.

4.1.5 Self-sufficiency ratio:

The percentage of fish self-sufficiency fluctuated during the study period, reaching a minimum of 81.1% in 2012, while the maximum reached about 87.1% in 2013, with an average of 84.6 during the study period. The predictive values of the fish self-sufficiency rate for the period (2023-2030), ranged between 83.4 in 2023 and 85.2% in 2030.

4.1.6 Number of fish available for consumption in Egypt:

In 2010, there were approximately 1.6 million tonnes of fish available for consumption in Egypt, which increased to 2.5 million tonnes in 2019, with an average of 1.7 million tonnes over the period (2010-2019). estimating the equation of the time trend of the quantity

available for consumption of fish in Egypt. It increased with a moral and statistical significance at a significant level of 0.01 with an increasing annual growth rate of 5.2%, where it reached (F) about 133.69, and the value of the coefficient of determination was (R^2) about 0.94, which means that 94% of the variables in the number of fish available for consumption in Egypt are due to factors reflected by time (Hany. et.al, 2022). Predictive values for the quantity of fish available for consumption in Egypt for the period (2023-2030) ranged from 2.7 million tonnes in 2023 to around 3.1 million tonnes in 2030 (El-Mahi et al., 2022).

4.2 Fish Microeconomics in Egypt:

4.2.1 Production function:

under Standard estimate of the production function of mixed fish (tilapia and mullet) for fish farms in the study sample, some factors that are supposed to affect the amount of fish production have been identified based on the assumptions of the production theory and what was included in previous studies in this field, the nature of the data available in the research sample, and the capabilities of the fish production function, as the quantity of fish produced is a mixture of mullet and tilapia during the production cycle period are dependent variables estimated in tonnes and the variables that explain the factors of production involved in the production of fish from those farms. They are considered the best mathematical images that agree with the economic and statistical logic for the ease of their calculation and for obtaining the production flexibility for each element directly.

Y_1 represents the quantity of fish produced, in tons, (The dependent variable).

The inputs to the production function are represented by the following independent variables:

X_1; The area of the square basins, estimated in acres.
X_2; The number of fingerlings, estimated in thousand units.
X_3; The amount of concentrated feed, estimated in tons.
X_4; The amount of chemical fertilization, in kilograms.
X_5; Organic fertilization, in cubic meters.
X_6; Number of labor (man/day)
X_7; The amount of fuel and oil (liters)
X_8; The experience of the farm manager in working in fish production (year)
X_9: The duration of the production cycle is a month

The results of the two-stage logarithmic model of the production function indicate the most influential variables on fish production in the study sample farms after excluding the variables that were found to be inconsistent with the economic or statistical logic of the significance of the function as a whole based on the (F) test at the level of significance of 0.01, and the significance of the coefficients of the independent variables based on the (T) test for each variable. So, there is a positive relationship between the quantity of fish production and each of the following: the number of fingerlings (X_2), the amount of concentrated feed (X_3), organic fertilization (X_5), the number of labor (X_6), the amount of fuel and oil (X_7), and the experience of the farm manager (X_8). It highlights the positive effect of these variables on the production of mixed fish (tilapia and mullet).

The coefficient of determination was about 95%, it means that the independent variables included in the model explain about 95% of the changes that occur in the production of mixed fish (tilapia and mullet) for the total sample in Fayoum Governorate during the productive season.

The logarithmic model reveals that the elasticity coefficients for the independent variables are less than one. It reflects the relationship of decreasing return to yield, as it increases the number of units used in production by 10% in both the fingerlings (feeds) (X_2), the amount of concentrated feed (X_3), and organic fertilization (X_5), the number of labor (X_6), and the experience of the farm manager (X_8). It led to an increase in production by about 1.72%, 4.21%, 1.32%, 1.18%, and 0.56%, respectively, which indicates that the use of these elements is in the economic stage.

The independent variables in the function can be arranged according to the relative importance of their impact on the fish mixture (Mullet and Tilapia) based on the regression coefficients, where the variable feed quantity (X_3) occupies the first place, followed by the organic fertilisation (X_5), the number of fingerlings (X_2), the number of labor (X_6), the duration of the production cycle (X_9), the amount of oil and fuel (X_7), and finally the experience of the farm manager (X_8). The overall production elasticity coefficient of the statistically studied elements was 1.2. It shows that the producers are in the first productive stage, which is the non-economic stage of the law of diminishing returns, due to the non-optimal use of the productive elements in the farms of the study sample, which requires re-mixing the used production elements in a way that shares the optimal combination and efficient use.

4.2.2. Cost function

The total cost function was estimated using three forms of cost functions (Linear, quadratic, and cubic). It is found based on the statistical tests (T, F, R^2) that are related to the problems of estimating the function at a significant level of 1% and the agreement of the signs with the economic theory. The production cost function was estimated in the short term for the research sample in Fayoum Governorate, where the production cost function expresses the relationship between the total costs of fish production in the sample farms (TC) and the quantity of production (Y) by which the average total costs and marginal costs were calculated, the optimum production limit. It is the scale at which average total costs reach their lowest level and equal marginal costs. Economic volume can also be calculated. It is the volume at which marginal costs are equal to price.

Under the quadratic relationship between total costs and the quantity of fish output (tilapia and mullet), the productivity changes explained about 96% of the change in production costs, and the flexibility of production costs at this level of production was estimated at about 1.86. This indicates that the production is undergoing a yield-increasing phase. This means that a certain percentage increase in production can be obtained for a smaller percentage increase in costs. The optimum volume of production during the season of production for the study sample amounted to 59 tonnes per farm. This was achieved by 19 farms, representing 47.5% of the number of farms in the sample. The volume of production reached 83 tons, while the rest of the sample items did not achieve this volume.

The average operating cost per acre amounted to 50.8 thousand EGP. The average cost of feeding, represented in feed, ranked first among the items of operational costs, as it amounted to about 55.1 percent of the average total operating costs. The average value of the fingerlings in second place; the average value of tilapia and mullet fingerlings was among the items of operational costs. Its relative importance among the items of operational costs was 11.5%. The average cost of permanent and seasonal labour came in third place, where it reached 7.2% of the average total operating costs. The average annual maintenance came in fourth place among the items of operational costs, reaching 5.3% of the average total. The value of the average fixed and variable costs per acre amounted to 13.2% and 86.8%, respectively, of the average total operating costs (see: Fig.3).

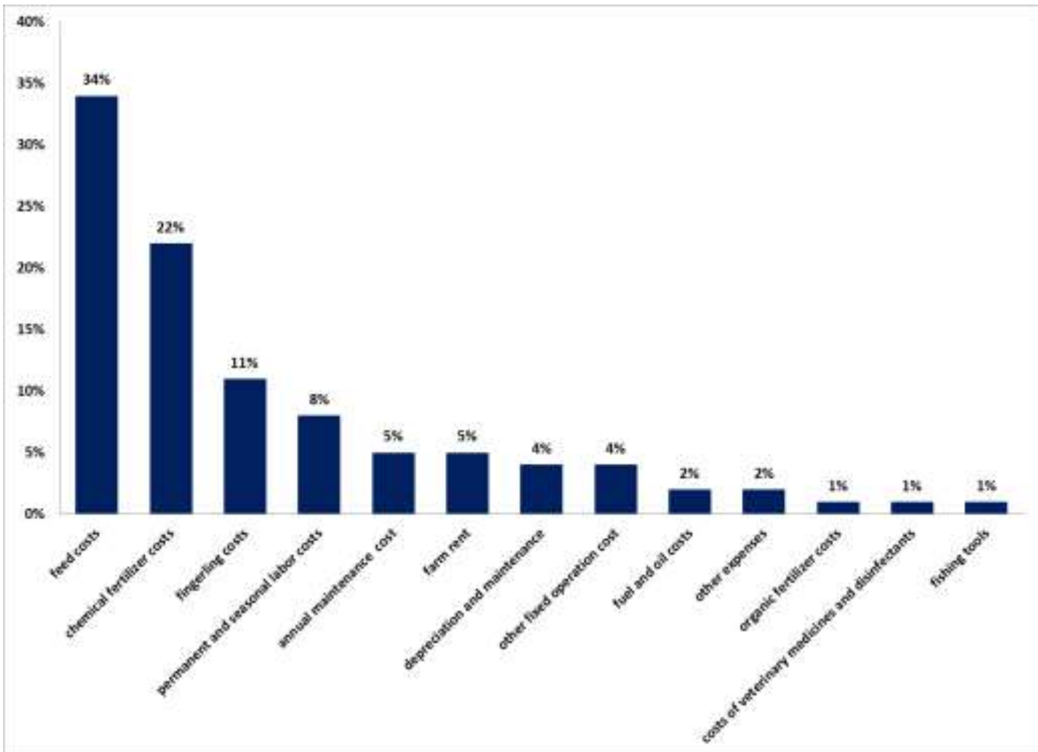

Fig 3. The aquaculture farms' Cost Structure

Fig. 3 details the aquaculture farms' Cost Structure since the feed costs (34%) and chemical fertilizer costs (22%) share the majority of the variable costs (56%).

4.2.3 Profitability analysis

The results showed the economic indicators of how well tilapia and mullet fish were produced per acre in the sample farms in Fayoum Governorate:

- **Revenues: The total revenues amounted to 114 EGP per acre.**
- **Profit or loss: The net profit amounted to 56 thousand EGP per acre.**
- **Revenues to costs ratio: The ratio of the total revenues to the total costs amounted to about 1.9, up from 1. This indicates the extent of profitability and economic feasibility of the productive project**
- **Break-even point: The quantitative break-even point has reached about 0.34, which means that the production process is in the interest of the farm owners.**

Accordingly, profitability analysis in the sample farms of fish has a positive impact. This requires encouraging farm owners to continue and expand these production projects and solve the problems facing producers.

5. Conclusion and Recommendations

5.1 Conclusion

Within the framework of the national plan adopted by the Egyptian government in recent years, fish production has expanded to about

418,6 thousand tons in 2020 from natural fisheries. but fish farming reached to 1.59 million tonnes in 2020 (comparing to 1.64 million tonnes in 2019, decreasing by 3%). fish production has increased in many areas of Fayoum, Kafr El-Sheikh, Damietta, Port Said, and others. The amount of fish that is grown on farms has tripled, and that number is likely to keep going up.

Based on the fish production function, the independent variables in the function can be arranged according to the relative importance of their impact on the fish mixture (mullet and tilapia), where the variable feed quantity occupies the first place, followed by the organic fertilisation, the number of fingerlings, the number of employees, the duration of the production cycle, the amount of oil and fuel, and finally the experience of the farm manager. But, with the recent changes in the fish market regionally and internationally, the costs have been strongly affected. Today, the value of the average fixed and variable costs per acre amounted to 13.2% and 86.8%, respectively, of the average total operating costs.

The results showed the economic indicators of how well tilapia and mullet fish were produced per acre in the sample farms in Fayoum Governorate: the total revenues amounted to 114 EGP per acre; the net profit amounted to 56 thousand EGP per acre. The ratio of the total revenues to the total costs amounted to about 1.9, The quantitative break-even point has reached about 0.34, which means that the production process is in the interest of the farm owners.

Accordingly, profitability analysis in the sample farms of fish has a positive impact. This requires encouraging farm owners to continue and

expand these production projects and solve the problems facing producers.

5.2 Recommendations:

As recommendations, to achieve Egypt's vision for sustainable development, "Egypt Vision 2030," The Egyptian Ministry of finance is recommended to provide tax support for the aquacultures. In addition, The Central Bank of Egypt should provide credit programs at preferential rates to improve profitability rates in this important industry. The current study has a agreement with El-Naggar, et.al (2008) on more supporting for a fish producers' union to help create a good environment for fish farming and come up with plans for growing fish industries, getting more inputs, and making distribution and marketing channels better. So, the study proposes an action plan to increase fish farms in Egypt

- **A. Establish a government-funded program to provide financial assistance to farmers interested in establishing fish farms.**
- **B. Provide technical assistance and training to farmers on the best practices for fish farming, including water management, feed management, and disease control.**
- **C. Establish a network of experts and advisors to provide advice and support to farmers on the best practices for fish farming.**
- **D. Create incentives for farmers to invest in fish farming, such as tax breaks or subsidies.**
- **E. Develop a marketing strategy to promote the benefits of fish farming in Egypt, including its potential economic benefits and environmental benefits.**
- **F. Increase public awareness of the importance of sustainable aquaculture through educational campaigns and outreach initiatives.**

G. Encourage research into new technologies that can improve the efficiency of fish farming operations in Egypt.
H. Establish regulations that ensure the safety and quality of farmed fish products in Egypt, as well as protect wild populations from overfishing or other environmental damage caused by aquaculture operations.
I. Work with local communities to ensure that any new aquaculture operations are socially responsible and do not cause any negative impacts on local ecosystems or communities.
J. Develop partnerships with international organizations that can provide additional resources and expertise for increasing fish farms in Egypt, such as funding for research or technical assistance programs for farmers interested in establishing aquaculture operations in their area

The study, on the other hand, proposes an action plan to increase fish catch in Egypt from the Mediterranean and the Red Sea.

A. Increase the number of fishing boats in the Mediterranean and Red Sea by providing subsidies to local fishermen.
B. Implement a strict catch-and-release policy for certain species of fish to ensure sustainable fishing practices.
C. Establish marine protected areas (MPAs) in both seas to help preserve fish stocks and promote healthy ecosystems.
D. Provide training and resources to local fishermen on sustainable fishing practices, such as using nets with smaller mesh sizes and avoiding overfishing.
E. Introduce new technologies such as sonar, GPS, and satellite imagery to help fishermen locate fish more accurately and efficiently.
F. Create incentives for local communities to conserve fish stocks by investing in alternative livelihoods such as aquaculture or tourism activities that are less reliant on fishing resources.

In addition to the above; The study proposes an action plan to develop fisheries in the High Dam Lake

A. Establish a Fisheries Management Plan: Develop a comprehensive fisheries management plan that outlines the

objectives, strategies, and activities necessary to develop and sustain a healthy fishery in the High Dam Lake.

B. **Monitor Fish Populations: Establish a monitoring program to track fish populations in the lake, including species composition, abundance, size structure, and other relevant data.**
C. **Stock Fish: Introduce appropriate fish species into the lake to increase fish populations and improve fishing opportunities.**
D. **Improve Habitat Quality: Implement habitat improvement projects such as creating spawning beds, adding cover structures, and improving water quality to create an environment conducive to healthy fish populations.**
E. **Educate Anglers: Develop educational materials for anglers about responsible fishing practices such as catch-and-release techniques and proper handling of fish to ensure sustainable fishing practices in the lake.**
F. **Enforce Regulations: Establish regulations for fishing in the lake and enforce them through regular patrols by fisheries personnel and law enforcement officers.**
G. **Promote Fishing Opportunities: Promote fishing opportunities in the High Dam Lake through public outreach efforts such as advertising campaigns, social media posts, and other forms of communication to attract anglers from around the region.**

Finally, the study recommends increasing the scope of scientific research in fish development in Egypt, as it is one of the areas of sustainable development, which makes it a task for academics to develop practises through research programmes with the faculties of business, agriculture, and science, each of them in their specialization.

References

Abdel-Aziz, M. F. A., Hassan, H. U., Yones, A. M., Abdel-Tawwab, Y. A., & Metwalli, A. A. A. T. (2021). Assessing the effect of different feeding frequencies combined with stocking density, initial weight, and dietary protein ratio on the growth performance of tilapia, catfish and carp. Scientific African, 12, e00806

Abdelbaki, A. M. (2021). Suggested solutions for the problems of salinity increase and cumulated pollution in Lake Qarun, Egypt: present and future (A review). Ain Shams Engineering Journal. 13(3),1015882

Adeleke, B., Robertson-Andersson, D., Moodley, G., & Taylor, S. (2020). Aquaculture in Africa: A comparative review of Egypt, Nigeria, and Uganda vis-a-vis South Africa. Reviews in Fisheries Science & Aquaculture, 29(2), 167-197.

Aïzonou, R., Achoh, M. E., Hountcheme, I. A. C., Agadjihouèdé, H., Ahouanssou-Montcho, S., & Montchowui, E. (2021). Zootechnical Knowledge of floating cage aquaculture in freshwaters ecosystems and load capacity determination. The Egyptian Journal of Aquatic Research, 47(1), 81-86.

Ashour, M. (2020). Current and future perspectives of microalgae-aquaculture in Egypt, case study: SIMAF-prototype-project. Egyptian Journal of Animal Production, 57(Suppl. Issue), 163-170.

Avadí, A., Cole, S. M., Kruijssen, F., Dabat, M. H., & Mungule, C. M. (2022). How to enhance the sustainability and inclusiveness of smallholder aquaculture production systems in Zambia?. Aquaculture, 547, 737494

Calleja, F., Guzmán, J. C., & Chavarría, H. A. (2022). Marine aquaculture in the pacific coast of Costa Rica: Identifying the optimum areas for a sustainable development. Ocean & Coastal Management, 219, 106033.

Debebe, S., & Bessie, S. (2022). Private Sector Development in Ethiopia: Trends, Challenges and Policy Issues.Policy Working Paper 04/2022

Deng, G. T. (2020). Assessment of factors affecting fish production and marketing in Gambella Region, Ethiopia. The scientific world journal, 5260693. https://doi.org/10.1155/2020/5260693

Dorji, N., Yamazaki, S., & Thinley, P. (2022). Productivity improvement to sustain small-scale fish production in developing countries: The case of Bhutan. Aquaculture, 548, 737612.

ElMahi, M., Kharoub, M., abdelrazek, Y., hagag, S. (2022). Landmarks and Indicators of Fish Production in Lake Nasser. Alexandria Science Exchange Journal, 43(3), 801-811.

El-Naggar, G. A. M. A. L., Nasr-Alla, A. H. M. E. D., & Kareem, R. O. (2008). Economic analysis of fish farming in Behera Governorate of Egypt. Conference Paper: Sustainable aquaculture, 2251.

Eltholth, M., Fornace, K., Grace, D., Rushton, J., & Häsler, B. (2018). Assessing the chemical and microbiological quality of farmed tilapia in Egyptian fresh fish markets. Global food security, 17, 14-20.

Feidi, I. (2018). Will the new large-scale aquaculture projects make Egypt self-sufficient in fish supplies?. Mediterranean Fisheries and Aquaculture Research, 1(1), 31-41.

Guyomard, H., Bouamra-Mechemache, Z., Chatellier, V., Delaby, L., Détang-Dessendre, C., Peyraud, J. L., & Requillart, V. (2021). Why and how to regulate animal production and consumption: The case of the European Union. Animal, 15(1), 100283

Hany, A., Akl, F., Hagras, M., & Balah, A. (2022). Assessment of recent rehabilitation projects' impact on water quality improvement in Lake Burullus, Egypt. Ain Shams Engineering Journal, 13(1), 101492.

Hassan, M., & Elbahy, E. F. (2022). Bacterial evaluation of the quality of farmED FISH of Kafr El-Sheikh city in EGYPT. Benha Veterinary Medical Journal, 41(2), 16-21.

Iliyasu, A., Mohamed, Z. A., & Terano, R. (2016). Comparative analysis of technical efficiency for different production culture systems and species of freshwater aquaculture in Peninsular Malaysia. Aquaculture Reports, 3, 51-57.

Justin, A. I., Kassam, D., & Sikawa, D. C. (2022). Integrating piggeries and aquaculture in Malawi: water quality and fish production. International Journal of Environmental Studies, 1-10. https://doi.org/10.1080/00207233.2022.2049174

Maina, J. G., Mbuthia, P. G., Ngugi, J., Omolo, B., Orina, P., Wangia, S. M., ... & Owiti, G. O. (2014). Influence of social-economic factors, gender and the Fish Farming Enterprise and Productivity Project on fish farming practices in Kenya. Development, 26(2).

Masi, M., Di Pasquale, J., Vecchio, Y., Pauselli, G., Tribilustova, E., & Adinolfi, F. (2022). A cross-sectional study in Mediterranean European countries to support stakeholders in addressing future market demands: Consumption of farmed fish products. Aquaculture Reports, 24, 101133.

Mavraganis, T., Constantina, C., Kolygas, M., Vidalis, K., & Nathanailides, C. (2020). Environmental issues of Aquaculture development. Egyptian Journal of Aquatic Biology and Fisheries, 24(2), 441-450.

Munguti, J. M., Nairuti, R., Iteba, J. O., Obiero, K. O., Kyule, D., Opiyo, M. A., ... & Ogello, E. O. (2022). Nile tilapia (Oreochromis niloticus Linnaeus, 1758) culture in Kenya: Emerging production technologies and socio-economic impacts on local livelihoods. Aquaculture, Fish and Fisheries, 2(4), 265-276.

Murphy, S., Charo-Karisa, H., Rajaratnam, S., Cole, S. M., McDougall, C., Nasr-Allah, A. M., ... & Ibrahim, N. (2020). Selective breeding trait preferences for farmed tilapia among low-income women and men consumers in Egypt: Implications

for pro-poor and gender-responsive fish breeding programmes. Aquaculture, 525, 735042.

Naglaa F. Soliman1, and Dalia M. M. Yacout, (2016), Aquaculture in Egypt: status, constraints and potentials , Springer International Publishing Switzerland. Feb, 2016.

Nasr-Allah, A., Gasparatos, A., Karanja, A., Dompreh, E. B., Murphy, S., Rossignoli, C. M., ... & Charo-Karisa, H. (2020). Employment generation in the Egyptian aquaculture value chain: implications for meeting the Sustainable Development Goals (SDGs). Aquaculture, 520, 734940.

Nobrega, R. O., Banze, J. F., Batista, R. O., & Fracalossi, D. M. (2020). Improving winter production of Nile tilapia: What can be done?. Aquaculture Reports, 18, 100453.

Otieno, N. E. (2019). Economic impact of predatory piscivorous birds on small-scale aquaculture farms in Kenya. Aquaculture Reports, 15, 100220.

Plamoottil, M., & Kumar B, P. (2022). Trends in Fisheries Production with emphasis on Aquaculture Fish Production: A Comparative Analysis of India and China. Egyptian Journal of Aquatic Biology and Fisheries, 26(3), 371-382.

Rahman, H., Mirza, J. A., Hossain, A., Al Asif, A., Haq, E., Chwakravorty, P., & Rahman, M. (2017). Economics of fish production in paddy fields in Bangladesh. Asian Journal of Medical and Biological Research, 3(3), 379-390.

Shaalan, M., El-Mahdy, M., Saleh, M., & El-Matbouli, M. (2018). Aquaculture in Egypt: insights on the current trends and future perspectives for sustainable development. Reviews in Fisheries Science & Aquaculture, 26(1), 99-110.

Tsiaras, K., Tsapakis, M., Gkanassos, A., Kalantzi, I., Petihakis, G., & Triantafyllou, G. (2022). Modelling the impact of finfish aquaculture waste on the environmental status in an Eastern Mediterranean Allocated Zone for Aquaculture. Continental Shelf Research, 234, 104647

Valderrama, D., Velasco, L. A., & Quiroz, N. (2016). Economic assessment of hatchery production of Argopecten nucleus spat

to support the development of scallop aquaculture in the wider Caribbean. Aquaculture Reports, 4, 169-177.

Valenti, W. C., Barros, H. P., Moraes-Valenti, P., Bueno, G. W., & Cavalli, R. O. (2021). Aquaculture in Brazil: past, present and future. Aquaculture Reports, 19, 100611

Wang, P., Ji, J., & Zhang, Y. (2020). Aquaculture extension system in China: development, challenges, and prospects. Aquaculture reports, 17, 100339.

Wanja, D. W., Mbuthia, P. G., Waruiru, R. M., Mwadime, J. M., Bebora, L. C., Nyaga, P. N., & Ngowi, H. A. (2020). Fish husbandry practices and water quality in central Kenya: potential risk factors for fish mortality and infectious diseases. Veterinary medicine international, 6839354. https://doi.org/10.1155/2020/6839354

Yue, G. H., Chang, A., Yuzer, A., & Suwanto, A. (2020). Current knowledge on the biology and aquaculture of the endangered Asian arowana. Reviews in Fisheries Science & Aquaculture, 28(2), 193-210.

Zwirn, M. (2002). Aquaculture in Egypt: Improving food security and resolving resource allocation conflicts. The Journal of Environment & Development, 11(2), 129-148.