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# An Economic Analysis of Fish Wealth in Egypt

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**ABSTRACT**

The research aimed to analyze the current status of fish production in Egypt from different sources. The study relied on quantitative and qualitative analytical statistical methods. It was found that the total fish production from natural fisheries represented only about 20.16% of the total fish production in Egypt. The results revealed a diversity of fish species produced on a commercial scale, with approximately 84.57% focused on three main types: tilapia, mullet, and sea bream. The most important variables affecting the quantity of fish production from natural fisheries was the number of fishermen and the number of mechanized fishing boats. Increasing these variables by 10% leads to an increase in the quantity of fish production from fisheries by 0.50 and 0.21%, respectively. The area of farms, the quantity of fish hatcheries production, and the real value of fry are considered the most important variables affecting the quantity of farmed fish production from fish farming. Increasing both hatcheries production quantity and the area of farms by 10% leads to an increase in the quantity of aquaculture production by 0.66 and 0.45%, respectively, while decreasing the real value of fry by 10% leads to an increase in the quantity of aquaculture production by 0.34%. The most important variables affecting the total quantity of fish consumption are the real retail price of red meat, the real retail price of tilapia, and the quantity of fish imports. It was found that a 10% decrease in the real retail price of tilapia leads to an increase in the quantity of fish consumption by 0.90%, while increasing both the real retail price of red meat and the quantity of fish imports by 10% leads to an increase in fish consumption by 3.2% and 1.96%, respectively.

## INTRODUCTION

Fish are considered a crucial food source for humans and can help meet the growing demand for animal protein, serving as an alternative to other protein sources. In developing countries, fish contribute about 30% of the total animal protein consumed per capita **(Wang *et al.*, 2015)**. Despite Egypt's vast water resources, including its location on the Mediterranean and Red seas, the presence of the Nile River and numerous lakes, fish production does not meet the needs of the Egyptian population. This has led to a fish food gap due to technical difficulties and some production issues. Therefore, there is a need to study and analyze the fish production and

consumption conditions in Egypt. This will help agricultural policymakers develop programs to promote the development of the fishery sector **(El-Seesy, 2006)**. The Egyptian fish production sector contributes approximately 72.74 billion Egyptian pounds (LE), equivalent to 9.89% of the total agricultural production value, which is about LE 735.78 billion, during the period from 2019 to 2022 **(MALR, 2022)**. The Arab Republic of Egypt has vast water areas and rich fisheries, including marine, lake & the Nile River fisheries, which together represent about 13 million water-feddan (1 feddan = 4200$m^2$). The domestic fish production quantity was about 1997 thousand tons with a value of approximately LE 59.39 billion. Fish imports amounted 379 thousand tons with a value of approximately 12.56 LE billion, while Egyptian fish exports reached about 29.37 thousand tons with a value of LE 704.32 million. The self-sufficiency rate was approximately 85.18% during the same period from 2018 to 2021 **(LFRPDA, 2021)**.

Egypt is suffering from continuous population growth, which led to an increased demand for food in general and animal protein in particular, as it is relatively more affordable compared to other sources. The per capita fish consumption amplified from 9kg in the 1990s to up to 19kg in 2018, although Egypt has suitable climatic conditions for aquaculture and multiple sources of fish production, natural resources are subject to pollution and overfishing **(Mehanna, 2022)**, which affect the fish stock and lead to its deterioration year after year. This forces the country to increase imports to fill the deficit, placing a burden on the country's balance of payments. Therefore, it is necessary to study the different sources of fish production and develop it to meet the increasing demand of fish and increase self-sufficiency rate.

The primary objective of this research was to analyze the current situation of fish production from various sources in Egypt. This will be achieved by identifying local production, fish consumption in Egypt and its development, demonstrating the relative importance of fish production according to fish species. It also examined the most influential factors on fish production and consumption during 2005-2021.

## MATERIAL AND METHODS

The research obtained the necessary data to achieve its objectives from published and unpublished secondary data sources. The data for the current study were collected from the Ministry of Agriculture and Land Reclamation, the Central Agency for Public Mobilization and Statistics, the General Authority for Fish Resources Development, and the Bulletin of Fish Production Statistics (various issues). Additionally, specialized research studies in the field of fisheries were employed. This research relied on both descriptive and quantitative statistical analysis to fulfill its objectives. The study used general time trend equations and employed methods such as averages & percentages. It also utilized simple and multiple regression analysis to identify the most influential factors on fish production and consumption in Egypt during the study period. Multiple logarithmic linear regression was used to detect the relationship between dependent variable (one variable) and independent variables (two or more).

The equation of multiple log-linear regression is $\log \hat{Y}i=\alpha+\beta X$.

Y: Dependent variable X: In Dependent variable;

B: Regression coefficient.

The Breusch-Pagan test was used to determine whether or not heteroscedasticity is existing in the regression model. Breusch- Godfrey test was used to see if there is autocorrelation in errors in the regression model. The ADF (Augmented Dickey-Fuller) test was used to discover if a time series is stationary or not.

## RESULTS

### 1. The most important economic variables and indicators for fish wealth in Egypt

The overall average for the local production of fish during the period from 2005-2021 reached 1473 thousand tons and LE 28,142 million, respectively, as indicated in Table (1), and increased with an annual significant growth rate by 4.59 and 13.28% for each of them, respectively (The general time trend equation, Table 2). The overall average quantity and value of Egyptian fish imports reached about 281 thousand tons and LE 5.89 billion, respectively, as shown in Table (1). The results of estimating the general time trend indicated a statistically significant increase at an annual growth rate of about 5.20 and 18.48%, respectively (Table 2). Meanwhile, the overall average quantity and value of Egyptian fish exports reached about 19.49 thousand tons and 312.66 million pounds, respectively. The results of estimating the general time trend indicated their increase at a statistically significant annual growth rate by 11.13 and 18.15%, respectively (The general time trend equation, Table 2).

The available quantity for consumption and the per capita share of fish in Egypt amounted 1.73 million tons and 19.96kg/ year, respectively, during the study period from 2005 to 2021. The available for consumption and the per capita consumption significantly increased with a growth rate of 5.14 and 2.77%, respectively. The self-sufficiency of fish in Egypt was 84.94% during the study period.

### 2. The relative importance of fish production sources

As presented in Table (3) and Fig. (1), the marine fish production during 2016 to 2021 reached about 102,348 thousand tons, which represented 5.33% of the overall average quantity of the Egyptian fish production (1,919,224 tons). It was clear that the average quantity of fish production from lakes (northern - inland - coastal depressions) was 208483 tons, representing about 10.86% of the overall average quantity of fish production. The average quantity of fish production from the Nile River and its branches was approximately 76,061,7 tons, representing about 3.96% of the overall average fish production. The total fish production from natural fisheries was 386,217, representing 20.16% of the overall average quantity of Egyptian fish production (1,919,224 tons) during the period from 2016 to 2021.

**Table 1.** Local production, imports, exports, available of consumption, per capita consumption, self-sufficiency and gap size of fish during the period from 2005 to 2021

| Item | Local Production | | Imports | | Exports | | Available for consumption* | Average consumption | Self-sufficiency | Fish gap size *** |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value | | | | |
| | Thousand tons | Million LE | Thousand tons | Million LE | Thousand tons | Million LE | Thousand tons | Capita/year/kg | % | Thousand tons |
| Year | | | | | | | | | | |
| **2005** | 889 | 7828 | 189 | 524 | 5.12 | 22.98 | 1072 | 15.32 | 82.90 | 186 |
| **2006** | 971 | 9305 | 208 | 593 | 4.05 | 19.33 | 1174 | 16.62 | 82.67 | 202 |
| **2007** | 1008 | 10827 | 259 | 1222 | 4.42 | 25.35 | 1263 | 16.98 | 79.84 | 217 |
| **2008** | 1068 | 10814 | 137 | 2035 | 6.73 | 59.51 | 1198 | 15.95 | 89.14 | 83 |
| **2009** | 1093 | 11662 | 136 | - | 7.59 | - | 1206 | 15.89 | 90.64 | 171 |
| **2010** | 1305 | 14495 | 257 | 2781 | 10.60 | 85.70 | 1551 | 19.70 | 84.13 | 176 |
| **2011** | 1362 | 16819 | 182 | 3106 | 9.49 | 140.03 | 1535 | 19.09 | 88.75 | 164 |
| **2012** | 1372 | 17652 | 335 | 4769 | 15.81 | 112.63 | 1691 | 20.55 | 81.12 | 233 |
| **2013** | 1454 | 19629 | 236 | 2984 | 20.45 | 161.92 | 1670 | 19.73 | 87.10 | 181 |
| **2014** | 1482 | 22280 | 355 | 5354 | 28.00 | 239.47 | 1808 | 20.83 | 81.94 | 222 |
| **2015** | 1519 | 23409 | 296 | 5753 | 19.70 | 236.05 | 1795 | 20.18 | 84.61 | 188 |
| **2016** | 1706 | 32309 | 311 | 4805 | 47.81 | 432.98 | 1970 | 21.64 | 86.63 | 122 |
| **2017** | 1823 | 43811 | 367 | 10087 | 34.11 | 649.34 | 2154 | 22.72 | 84.61 | 307 |
| **2018** | 1935 | 48251 | 324 | 12306 | 26.30 | 578.22 | 2233 | 22.98 | 86.66 | 355 |
| **2019** | 2039 | 61084 | 506 | 13809 | 35.01 | 885.89 | 2510 | 25.38 | 81.24 | 524 |
| **2020** | 2011 | 61884 | 300 | 10821 | 28.11 | 547.99 | 2282 | 22.68 | 88.10 | 572 |
| **2021** | 2002 | 66353 | 385 | 13293 | 28.07 | 805.19 | 2359 | 23.12 | 84.86 | 226 |
| **The overall Average** | 1473 | 28142 | 281 | 5890 | 19.49 | 312.66 | 1733.59 | 19.96 | 84.94 ** | 243 |

*Available quantity for consumption = Local production + imports - Exports ** Geometric mean

*** Fish gap size = Local production – available quantity of consumption

Source: - Data collected from the Ministry of Agriculture and Land Reclamation, General Authority for Fish Resources Development, the Bulletin of Fish Production Statistics - various issues.

**Table 2.** The general time trend equations of the most important economic variables and indicators of fish in Egypt during the period from 2005 to 2021

| No | Variable | Equation | $R^2$ | t | F | Mean | Rate of change % |
|---|---|---|---|---|---|---|---|
| **1** | Production quantity (thousand tons) | ^y1=783.5+76.60 h1x | 0.98 | 25.09** | 629.45** | 1473 | 4.59 |
| **2** | Production value (million LE) | ^y2= -5464+3737 h2x | 0.87 | 10.06** | 101.14** | 28142 | 13.28 |
| **3** | Imports quantity (thousand tons) | ^y3= 149.8+14.62 h3x | 0.58 | 4.60** | 21.14** | 281 | 5.20 |
| **4** | Imports value (million LE) | ^y4= -1864+912 h4x | 0.87 | 9.98 ** | 99.68** | 5890 | 18.48 |
| **5** | Exports quantity (thousand tons) | ^y5= -.002+2.17 h5x | 0.71 | 6.07** | 36.85** | 19.49 | 11.13 |
| **6** | Exports value (million LE) | ^y6= -170+56.76 h6x | 0.84 | 8.73** | 76.18** | 312.66 | 18.15 |
| **7** | Available for consumption (thousand tons) | ^y7=930.8+89.20 h7x | 0.95 | 17.69** | 312.90** | 1733.59 | 5.14 |
| **8** | Average capita consumption( kg/year) | ^y8=14.98+0.554 h8x | 0.88 | 10.38** | 107.83** | 19.96 | 2.77 |
| **9** | Self-sufficiency % | ^y9=84.43+0.063 h9x | 0.01 | 0.39 | 0.15 | 84.94* | - |

(**) is significant at the level of 0.01
y^ = the estimated value of the dependent variable h x = the time variable * The geometric mean of percentage
Rate of change = Regression coefficient / Variable average x 100
Source: - Collected from Table 1

**Table 3.** Fish production from the different sources in Egypt during 2016-2021

| Source | Natural fisheries | | | | Aquaculture ( fish farming) | Total |
|---|---|---|---|---|---|---|
| Year | Seas (marine) | Lakes | Nile River | Total | | |
| 2016 | 103,654 | 158,475 | 73,484 | 335,613 | 1,370,660 | 1,706,273 |
| 2017 | 109,764 | 183,463 | 77,732 | 370,959 | 1,451,841 | 1,822,800 |
| 2018 | 104,695 | 194,851 | 73,739 | 373,285 | 1,561,457 | 1,934,742 |
| 2019 | 98,953 | 220,713 | 77,376 | 397,042 | 1,641,949 | 2,038,991 |
| 2020 | 101,392 | 237,758 | 79,533 | 418,683 | 1,591,896 | 2,010,579 |
| 2021 | 95,627 | 255,636 | 74,506 | 425,769 | 1,576,189 | 2,001,958 |
| Average | 102,348 | 208483 | 76,061,7 | 386,217 | 1,532,332 | 1,919,224 |
| Total % | 5.33 | 10.86 | 3.96 | 20.16 | 79.84 | 100 |

Source: Ministry of Agriculture and Land Reclamation, General Authority fish resources development, Annual Fisheries Statistics Book, Thirtieth Edition, 2021, p. 19.

As mentioned earlier, aquaculture (fish farming) is the most important source of fish production. The Egyptian government encouraged the expansion of fish production from fish farms. Aquaculture production in Egypt is the largest in Africa with about one million tons per annum **(Shaalan *et al*., 2017)**. Fish farms have contributed to approximately 79.84% of the total fish production during the period from 2016 to 2021, with the aim of providing more fish for consumption, hence reducing the fish food gap **(El-Bana 2016)**. Moreover, aquaculture industry provides about 77% of the total domestic fish production **(El-Sayed *et al*., 2015; FAO, 2016)**.

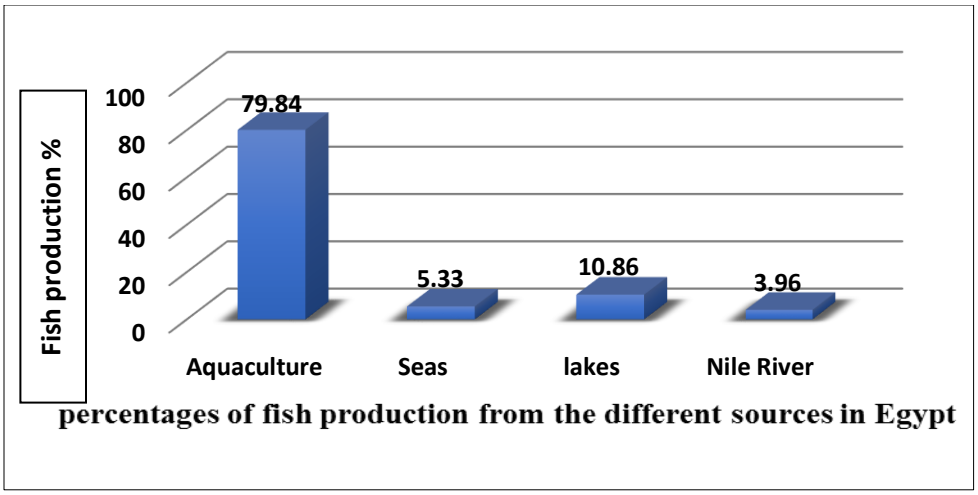


**Fig. 1.** Percentages of fish production from the different sources of in Egypt during the period from 2016 to 2021

### *2.1 Fish production evolution from fish farming systems in Egypt*

The various fish farming patterns in Egypt are diverse, as illustrated in Fig. (2). Fish farming is the process in which fish are raised in an enclosed area for the purpose of economic and commercial production, under favorable conditions, where they were fed and protected from predators. The semi-intensive aquaculture in earthen ponds is considered the most widespread and important fish farming system in Egypt. **Shaalan *et al*. (2018)** reported that the majority of the Egyptian fish production (>85%) is based on earthen ponds situated within and around the Nile Delta and its associated lakes. Fish farming industry is part of the profitable investment projects in the field of food security.

***A. Fish production from governmental farms***

Governmental farms in Egypt are established and supervized by the General Authority for Fish Resources Development. Fish production from governmental farms represents only 0.99% of the total fish production in Egypt. Data from Table (4) show that fish production from governmental farms witnessed a clear fluctuation during the study period (2005-2021), as it was 7.59 thousand tons in 2005, and increased to 17501 thousand tons in 2021.

The total fish production from governmental farms showed a significant yearly increase of about 588 tons at an annual rate of 5.38% of the overall average of fish production (10.922 thousand tons) for governmental farms during the period (2005-2021). The $R^2$ value was 0.70, which means that the changes reflected by the variable of time were responsible for about 70% of the changes that occurred in the total fish production in governmental farms, as indicated in Table (5).

***B. Fish production from private farms***

The production of private fish farms is estimated at about 907104 thousand tons, and fish production from private farms exhibited a clear increase during the study period (2005-2021), as it increased from 492246 thousand tons in 2005 to 1,410017 million tons in 2019, thereafter it decreased a little bit to 1.355287 million tons in 2021 (Table 4). The total fish production of

private farms significantly increased by an annual amount of 65.43 thousand tons; the annual rate of increase was about 7.21% of the overall average for the private farms being 907104 thousand tons during the period 2005-2021. The private farms have a leading role in fish production **(GAFRD, 2012)**. The $R^2$ value was 0.93, which means that the productive, technological and economic changes reflected by the variable of time were responsible for about 93% of the changes that occurred in the total production of fish farming in private farms during the study period (Table 5).

***C- Fish production from floating cages***

Floating cages are the most widespread intensive fish farming system in Egypt. Fish production from floating cages system fluctuated during the period from 2005 to 2021. It reached 19839 thousand tons in 2005 and increased in 2021 to 195764 thousand tons, as indicated in Table (4). The equation of general time trend number 3 showed that the total fish production from cages has taken an increasing trend by an annual quantity of 9.45 thousand tons with an annual rate of 5.93% of the overall average of fish production (159382 thousand tons) during the studied period (2005-2021). Additionally, the $R^2$ value was 0.38, which means that about 38% of the changes in total fish production were due to time, as indicated in Table (5).

***D - Fish production from rice fields***

Fish production from rice fields was 17.603 thousand tons in 2005. However, it decreased markedly in 2021 being 5525 thousand tons (Table 4). This decline in production may be due to many constraints such as decreasing the cultivated area of rice crop by 63%. By estimating the general time trend equation (No.4), it is clear that the total production from rice fields did not prove any statistically significant difference (Table 5).

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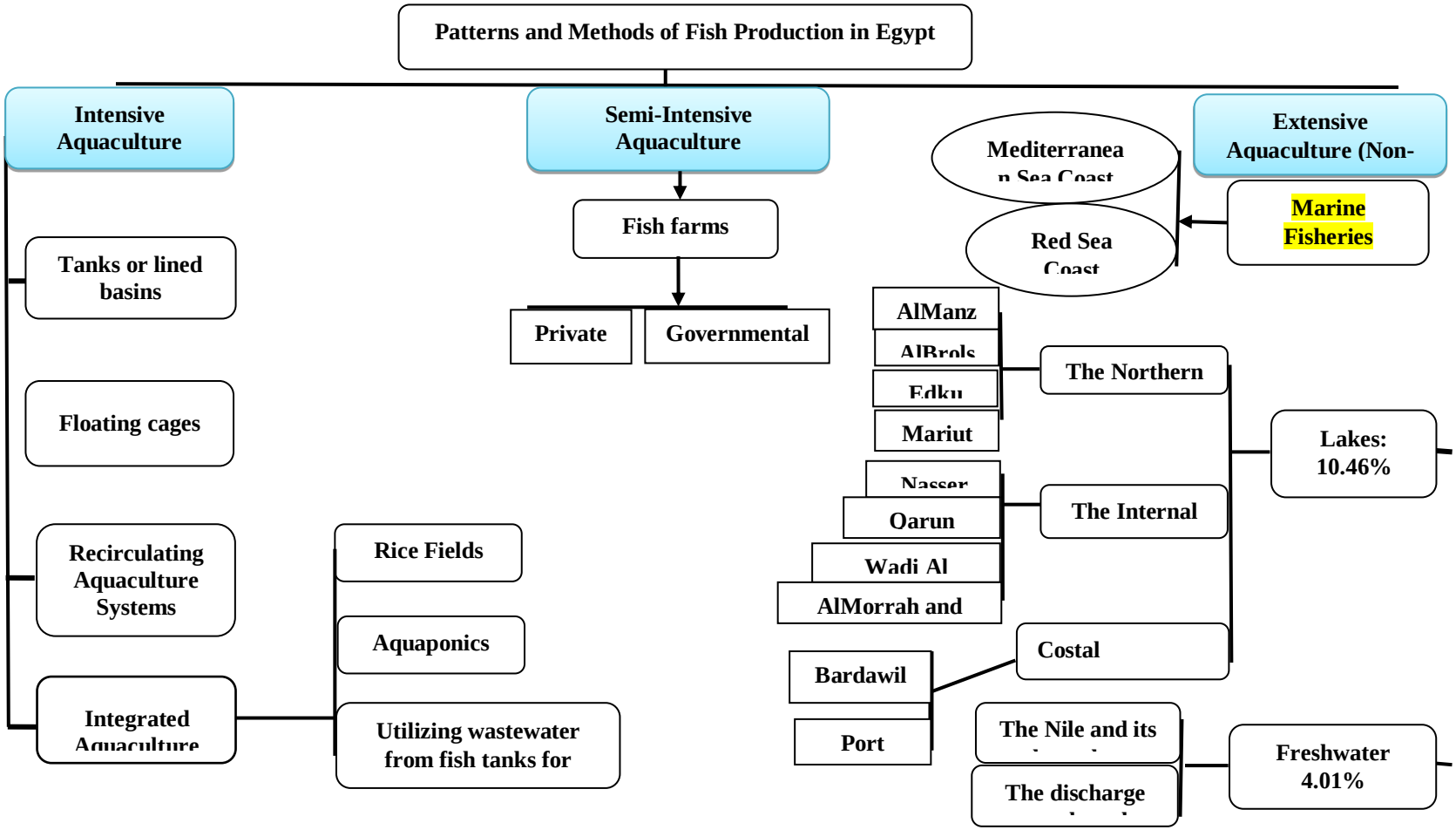


**Fig. 2.** Various patterns and methods of fish production in Egypt

Source: Researcher's Design based on the categorization of the Ministry of Agriculture and Land Reclamation, General Authority for Fisheries Development, Annual Fisheries Statistics Book, Thirtieth Edition, 2020.

**Table 4.** Yearly evolution of the different types of fish farming during the period from 2005 to 2021. (Production Quantity: in Tons)

| Item | Fish farming systems | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Semi-intensive production | | | Intensive production | | | | Total production from fish farming |
| Year | Governmental | Private | High prod. Semi-intensive | Intensive | Cage fish | Raceways * | Rice fields | |
| 2005 | 7588 | 492246 | 2472 | - | 19839 | - | 17603 | 539748 |
| 2006 | 7955 | 498885 | 2472 | - | 80141 | - | 5576 | 595029 |
| 2007 | 8539 | 557822 | 1580 | - | 62276 | - | 5300 | 635517 |
| 2008 | 8547 | 586435 | 1825 | - | 69108 | - | 27900 | 693815 |
| 2009 | 6605 | 591276 | 1860 | - | 68049 | - | 37700 | 705490 |
| 2010 | 10680 | 716801 | 1893 | 700 | 160288 | - | 29223 | 919585 |
| 2011 | 10092 | 721684 | 3115 | 700 | 216122 | - | 35107 | 986820 |
| 2012 | 9509 | 720412 | 1451 | 2444 | 249385 | - | 34537 | 1017738 |
| 2013 | 9300 | 722870 | 1451 | 2444 | 327344 | - | 34135 | 1097544 |
| 2014 | 8255 | 916757 | - | 1835 | 176266 | - | 33978 | 1137091 |
| 2015 | 9747 | 972503 | - | 2412 | 172632 | - | 17537 | 1174831 |
| 2016 | 13078 | 1166147 | - | 2268 | 175632 | - | 13535 | 1370660 |
| 2017 | 12190 | 1260735 | - | 1912 | 169269 | - | 7735 | 1451841 |
| 2018 | 13652 | 1368314 | - | 2324 | 165352 | 18 | 11797 | 1561457 |
| 2019 | 12611 | 1410017 | - | 2420 | 200980 | 28 | 15893 | 1641949 |
| 2020 | 19822 | 1362577 | - | 2447 | 201040 | 68 | 5942 | 1591896 |
| 2021 | 17501 | 1355287 | - | 2042 | 195764 | 70 | 5525 | 1576189 |
| The overall Average | 10922 | 907104 | 1066 | 1409 | 159382 | 11 | 19943 | 1099835 |
| Total% | 0.99 | 82.84 | 0.10 | 0.13 | 14.49 | 0.00 | 1.81 | 100 |

(*) This system was implemented in 2018.

Source: Ministry of Agriculture and Land Reclamation, General Authority for Fisheries Development, Annual Fisheries Statistics Book, Various Issues.

**Table 5.** The general time trend equations of fish production under different fish farming systems in Egypt during the period (2005 - 2021)

| No | Variable | Equation | $R^2$ | t | F | Mean | Rate of change % |
|---|---|---|---|---|---|---|---|
| 1 | Fish production from governmental farms | ^y1=5629 +588 h1x | 0.70 | 5.86** | 34.29** | 10922 | 5.38 |
| 2 | Fish production from private farms | ^y2=-318209 +65433 h2x | 0.93 | 14.40** | 207,35** | 907104 | 7.21 |
| 3 | Fish production from cage system | ^y3=74280 +9456 h3x | 0.38 | 3.01** | 9.06** | 159382 | 5.93 |
| 4 | Fish production from rice fields | ^y4= 26861 – 769 h4x | 0.10 | -1.29 | 1.66 ** | 19943 | - |
| 5 | Total fish production | ^y5=-427473+74707h5x | 0.97 | 23.29** | 572,36** | 1099835 | 6.79 |

(**) Significant at 0.01 level.
Rate of change = Regression coefficient / Phenomenon average x 100
(^y) Estimated value of the phenomenon under study.
(h X) Time factor in years 1, 2,
Source: Calculated from Table (4).

**E-** ***The total fish production from the different fish farming systems in Egypt***

Total fish production from fish farming in Egypt increased gradually from 2005 until 2019, where it was 539.75 thousand tons in 2005 and increased throughout the aforementioned period reaching its maximum quantity in 2019 (1.642 million tons), as shown in Table (4). However, it decreased in 2021 being 1.58 million tons. This reduction of production refers to decreasing the operating farms, especially the private one due to water shortage, in addition to a nearly 63% decrease of the cultivated area of rice fields. By estimating the general time trend equation, the total fish production from all the farming systems showed a significant ($P< 0.05$) yearly increase of about 74.71 thousand tons at an annual rate of 6.79% of the overall average of fish production (1.10 million tons) during the period (2005-2021). The $R^2$ value was 0.97, which means that the changes occurred by the variable of time (such as economical, managerial, and technology adoption) were responsible for about 97% of the changes that occurred in the total production from fish farming during the studied period (2005-2021), as indicated in Table (5).

**3. The relative distribution of the most important fish species produced from various sources in Egypt**

The number of fish species commercially produced in Egypt exceeds fifty species. Undoubtedly, these fish species vary greatly in many of their natural traits, breeding seasons, strength of generations, and sizes at maturity **(Soliman & Amer, 2002)**. An analysis of the relative importance of fish production in Egypt shows that around 84.57% is concentrated in three main species: tilapia, mullet, and carp, during the period from 2015 to 2021.

The data in Table (6) indicates that the total fish production from 2015 to 2021 amounted 1.86 million tons. Tilapia came in first place with a production of 1.11 million tons, about 59.55% of the total fish production for Egypt. It is followed by the mullet in second place with a production quantity of 276.45 thousand tons, (about 14.85%), and lastly the carp with 189.28 thousand tons (10.17%). Other species such as the catfish, gilt-head bream, sea bass, and meagre,

recorded 43.18, 33.83, 28.87, and 24.53 thousand tons, respectively, accounting for approximately 2.32, 1.82, 1.55, and 1.32% of the average fish production, respectively.

**Table 6.** Main fish species produced in Egypt, the average for the period from 2015 to 2021. (Quantity in tons)

| Sources / Species | Natural fisheries | | | | | Aquaculture | | Overall total | % |
|---|---|---|---|---|---|---|---|---|---|
| | Marine | Lakes | Nile River | Total | % | Total | % | | |
| Tilapia | - | 108,992 | 23,681 | 132,673 | 34.84 | 976255 | 65.91 | 1108928 | 59.55 |
| Mullet Family | 17,75 | 34,748 | 522 | 36,995 | 9.72 | 239460 | 16.17 | 276455 | 14.85 |
| Carp | - | 5715 | 10,393 | 16,108 | 4.23 | 173,177 | 1169 | 189,285 | 10.17 |
| Catfish | - | 20,609 | 14,367 | 34,977 | 9.19 | 8201 | 0.55 | 43,177 | 2.32 |
| Gilt-head bream | 386 | 1253 | - | 1639 | 0.43 | 32,190 | 2.17 | 33,829 | 1.82 |
| Sea bass | 279 | 1365 | - | 1644 | 0.43 | 27227 | 1.84 | 28,871 | 1.55 |
| Meagre | 789 | 192 | - | 981 | 0.26 | 23,545 | 1.59 | 24,526 | 1.32 |
| Sardines | 15,365 | 53 | - | 15,419 | 4.05 | - | 0.00 | 15,419 | 0.83 |
| Horse mackerel | 10,463 | - | - | 10,463 | 2.75 | - | 0.00 | 10,363 | 0.56 |
| Shrimp | 7838 | 4265 | - | 12,103 | 3.18 | 872 | 0.06 | 12,974 | 0.70 |
| Whitefish ( Bagrus) | 620 | 1561 | 5491 | 7673 | 2.02 | 287 | 0.02 | 7960 | 0.43 |
| Other species | 66,372 | 24,443 | 20,699 | 111,513 | 29.29 | 48 | 0.00 | 111,561 | 5.99 |
| Overall Total | 102,431 | 203,196 | 75,153 | 380,780 | 100 | 1,481,260 | 100 | 1,862,041 | 100 |

Source: Ministry of Agriculture and Land Reclamation, General Authority for Fisheries Development, Annual Fisheries Statistics Book, Various Issues.

## 4. The important factors affecting fish production from natural fisheries

The results of Unit Root Test 1 (Appendix 1) indicate that the values of time series for all variables are not stationary at their level but are stable at their first differences, which means that they are integrated of the first degree I (1) during the period from 2004-2021.

Multiple logarithmic regression model was used to determine and quantify the relationship between the dependent variable (Y, fish production / thousand ton) and independent variables which is

$X_1$ fishermen number (Thousand fisherman)
$X_2$ mechanized fishing boats (Thousand boat)
$X_3$ un-mechanized fishing boats (Thousand boat)
$X_4$ True price of tilapia fish (LE/kg)
$X_5$ Fish imports quantity (Thousand ton)
$X_6$ True value of fuel, oil, and depreciation for fish boats (Million LE)

The multiple regression was conducted after ensuring the stability of the data at the first difference. Many attempts were made to obtain the best possible statistical estimates. The best

functions were chosen according to the criteria of economic theory and statistical criteria. The best was in the double logarithmic form, as shown in Table (8). The results of the analysis show that the estimated model is acceptable from the economic and statistical perspective. It was shown that the most important explanatory variables affecting the quantity of fish production from natural fisheries in Egypt are the number of fishermen (Log $X_1$), and the number of mechanized fishing boats (Log $X_2$). The statistical significance of these variables was proven. The value of $R^2$ indicates that the independent factors are responsible for about 59% of the changes occurring in the quantity of fish production from natural fisheries in Egypt.

The model shows that there is a direct relationship between the number of fishermen, the number of mechanized fishing boats and the quantity of fish production from natural fisheries, at rates of 0.498 and 0.213%, respectively.

The dataset in the estimated model was tested for the normal distribution; the Jarque Bera test (JB) showed that the probability value was 0.7252, which was greater than 0.05, therefore the null hypothesis was accepted, meaning that the dataset is normally distributed. The Breusch-Pagan test in Table (9) shows no issue with variance instability, as the probability value of 0.4925 was greater than 0.05. Godfrey- Pagan test (Table 10) showed that there was no autocorrelation, the probability was 0.5944, which was greater than 0.05, meaning that there were no errors in autocorrelation, and therefore the model was statistically acceptable.

**Table 7.** The most important factors affecting fish production from natural fisheries during the period from 2004 - 2021

| Item<br>year | Total natural fisheries production<br>Thousand ton | The Number of fishermen<br>Thousand fisherman | Mechanized fishing boats<br>Thousand boat | Non-mechanized fishing boats<br>Thousand boat | Current price of tilapia fish<br>LE/kg | True price of tilapia fish<br>LE/kg | Fish imports quantity<br>Thousand ton | Current value of fuel, oil, and depreciation for fish boats<br>Million LE | True value of fuel, oil, and depreciation for fish boats<br>Million LE | Producer price general index number<br>Base year 2004- 2025 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 393.50 | 49.19 | 4.25 | 35.33 | 7.88 | 7.83 | 204.0 | 576.04 | 572.03 | 100.7 |
| 2005 | 349.55 | 49.85 | 4.38 | 30.99 | 7.34 | 6.82 | 188.5 | 600.91 | 558.47 | 107.6 |
| 2006 | 375.90 | 61.03 | 4.49 | 35.16 | 8.73 | 7.37 | 206.0 | 672.25 | 567.78 | 118.4 |
| 2007 | 372.49 | 55.03 | 4.54 | 34.51 | 9.42 | 7.27 | 220.8 | 771.82 | 596.00 | 129.5 |
| 2008 | 373.81 | 58.01 | 4.81 | 25.64 | 8.95 | 5.73 | 104.6 | 808.96 | 517.90 | 156.2 |
| 2009 | 387.40 | 65.55 | 4.71 | 30.27 | 9.90 | 6.72 | 147.0 | 652.01 | 442.34 | 147.4 |
| 2010 | 385.21 | 42.96 | 4.83 | 30.25 | 9.91 | 5.97 | 183.1 | 754.83 | 454.45 | 166.1 |
| 2011 | 375.35 | 43.47 | 4.85 | 24.69 | 11.59 | 6.08 | 175.0 | 876.67 | 460.20 | 190.5 |
| 2012 | 354.24 | 38.06 | 4.91 | 25.92 | 12.85 | 6.58 | 249.0 | 919.05 | 470.83 | 195.2 |
| 2013 | 356.86 | 31.15 | 4.86 | 24.28 | 14.59 | 7.23 | 202.8 | 899.05 | 445.51 | 201.8 |
| 2014 | 344.79 | 37.33 | 4.83 | 25.15 | 16.78 | 7.97 | 244.3 | 1165.72 | 553.79 | 210.5 |
| 2015 | 344.11 | 51.84 | 4.92 | 25.92 | 17.58 | 8.62 | 204.2 | 1387.08 | 680.28 | 203.9 |
| 2016 | 335.61 | 48.30 | 4.96 | 24.38 | 17.81 | 8.00 | 220.4 | 1551.99 | 696.89 | 222.7 |
| 2017 | 370.95 | 59.86 | 5.05 | 27.70 | 25.58 | 8.50 | 339.1 | 2040.73 | 678.44 | 300.8 |
| 2018 | 373.30 | 52.00 | 4.69 | 23.35 | 22.78 | 6.28 | 386.1 | 2744.54 | 756.70 | 362.7 |
| 2019 | 397.10 | 43.78 | 4.80 | 21.52 | 27.45 | 7.21 | 555.0 | 3663.16 | 961.71 | 380.9 |
| 2020 | 418.69 | 32.40 | 4.10 | 17.21 | 22.69 | 6.41 | 600.3 | 4826.72 | 1362.71 | 354.2 |
| 2021 | 425.78 | 34.59 | 3.71 | 23.38 | 22.78 | 6.20 | 323.3 | 5026.90 | 1367.68 | 367.6 |

- Tilapia fish represented the first class in natural fisheries production amounted 35%
- Current price of Tilapia fish and the current value of fuel oil, of fishing boats transferred to true value by using producer price general index number and the base year was 2004/2005
- True value = (current value ÷ Producer price general index number for 2004/2005 as a base year) ×100.

**Table 8.** The results of logarithmic multiple regression analysis for the study variables during the period 2004-2021.

| Variable | Coefficient | Std. Error | t-Statistic | Prob |
|---|---|---|---|---|
| C | 0.011361 | 0.003966 | 2.864882 | 0.0125 |
| $DLOGX_1$ | 0.049756 | 0.010818 | 4.599322 | 0.0004 |
| $DLOGX_2$ | 0.021295 | 0.006613 | 3.220143 | 0.0062 |
| R-squared | 0.644665 | Mean dependent var | 0.002014 | |
| Adjusted R-squared | 0.593902 | S.D. dependent var | 0.022568 | |
| S.E. of regression | 0.014382 | Akaike info criterion | -5.486959 | - |
| Sum squared resid | 0.002896 | Schwarz criterion | -5.339921 | |
| Log likelihood | 49.63915 | Hannan-Quinn critter | -5.472343 | |
| F-statistic | 12.69970 | Durbin-Watson stat | 2.239764 | |
| Prob(F-statistic) | 0.000715 | | - | |

Source. The results of Table (7) data analysis by E-Views.

**Table 9.** Breusch–Pagan test's results test to detect non-stationarity of variance

| | | | |
|---|---|---|---|
| F-statistic | 0.6364 | Prob. F(4,13) | 0.5438 |
| Obs*R-squared | 1.4167 | Prob. Chi-square(4) | 0.4925 |
| Scaled explained SS | 0.7209 | Prob. Chi-square(4) | 0.6974 |

**Table 10.** Godfrey- Pagan serial correlation

| | | | |
|---|---|---|---|
| F-statistic | 0.2205 | Prob. F(1,12) | 0.6464 |
| Obs*R-squared | 0.2836 | Prob. Chi-square(1) | 0.5944 |

## 5. The most important factors affecting the quantity of farmed fish production from fish farming

Fish production (Y) in thousand tons (dependent variable) from fish farming was affected by the most important economic independent variables during the period from 2004-2021, which were:

X1 The real product price of tilapia fish LE/kg
X2 Quantity of fish imports Thousand tons
X3 Quantity of fish hatcheries production (fry and fingerlings) Million units
X4 Quantity of fry production from fry collection centers Million units
X5 Area of fish farms Thousand feddan
X6 The real value of fish feed Million LE
X7 The real value of fry Million LE

**Table 11.** The most important factors affecting the quantity of farmed fish production from fish farming during the period 2004-2021

| Item / Year | Farmed fish quantity | True price of tilapia fish | Fish imports quantity | Fish hatcheries quantity | Quantity of fry production from fry collection centers | Area of fish farms | Fish feed current value | Real value of fish feed | Current value of fry | Real value of fry |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thousands ton | LE/kg | Thousand ton | Million unit | Million unit | Thousand feddan | Million LE | Million LE | Million LE | Million LE |
| 2004 | 471.54 | 7.83 | 204.0 | 354 | 96.0 | 207.51 | 5.18 | 5.14 | 105.11 | 104.38 |
| 2005 | 539.75 | 6.82 | 188.5 | 298 | 69.0 | 264.59 | 5.47 | 5.08 | 110.18 | 102.4 |
| 2006 | 595.03 | 7.37 | 206.0 | 270 | 41.0 | 335.30 | 6.02 | 5.08 | 117.89 | 99.57 |
| 2007 | 635.52 | 7.27 | 220.8 | 306 | 77.0 | 360.28 | 6.38 | 4.93 | 145.01 | 111.98 |
| 2008 | 693.82 | 5.73 | 104.6 | 347 | 77.0 | 359.37 | 6.89 | 4.41 | 154.71 | 99.05 |
| 2009 | 705.49 | 6.72 | 147.0 | 305 | 57.0 | 361.31 | 225.37 | 152.90 | 163.99 | 111.26 |
| 2010 | 919.59 | 5.97 | 183.1 | 400 | 78.0 | 305.03 | 345.25 | 207.86 | 190.23 | 114.53 |
| 2011 | 986.82 | 6.08 | 175.0 | 475 | 63.0 | 285.84 | 401.02 | 210.51 | 220.89 | 115.95 |
| 2012 | 1017.74 | 6.58 | 249.0 | 411 | 73.0 | 287.41 | 420.41 | 215.37 | 231.57 | 118.63 |
| 2013 | 1097.54 | 7.23 | 202.8 | 509 | 43.0 | 292.62 | 621.31 | 307.88 | 233.32 | 115.62 |
| 2014 | 1137.09 | 7.97 | 244.3 | 560 | 72.0 | 298.13 | 553.41 | 262.90 | 263.82 | 125.33 |
| 2015 | 1174.83 | 8.62 | 204.2 | 375 | 95.0 | 310.35 | 572.33 | 280.69 | 270.42 | 132.62 |
| 2016 | 1370.66 | 8.00 | 220.4 | 277 | 51.0 | 320.80 | 653.68 | 293.52 | 312.33 | 140.25 |
| 2017 | 1451.84 | 8.50 | 339.1 | 184.2 | 77.1 | 302.65 | 769.45 | 255.8 | 19.96 | 6.64 |
| 2018 | 1561.50 | 6.28 | 386.1 | 272 | 45.5 | 307.24 | 998.77 | 275.37 | 26.85 | 7.40 |
| 2019 | 1641.90 | 7.21 | 555.0 | 303.6 | 62.3 | 295.21 | 1107.01 | 290.63 | 28.58 | 7.50 |
| 2020 | 1591.90 | 6.41 | 600.3 | 673.9 | 46.7 | 307.11 | 21490.60 | 6067.36 | 968.75 | 273.50 |
| 2021 | 1576.19 | 6.20 | 323.3 | 900.3 | 49.4 | 300.96 | 23800.45 | 6475.43 | 1186.00 | 322.68 |

- Tilapia fish was used as it ranks first in natural fisheries production in Egypt, equivalent to about 65%
- Current price of tilapia and total current value of fish feed and fry were converted to real values using the producer price index for the base year (2004/2005).
- The area of fish farms includes the area of government farms and the area of private farms (owned, rented, and temporary)
- Source: Collected and calculated from: - Central Agency for Public Mobilization and Statistics, Annual Bulletin of Estimates of Income from the Agricultural Sector - Various Issues. - Ministry of Agriculture and Land Reclamation, General Authority for Fish Resources Development, Annual Fisheries Statistics Book, Various Issues. - Central Agency for Public Mobilization and Statistics, Annual Bulletin of Fish Production Statistics, Various Issues. - Central Agency for Public Mobilization and Statistics, Annual Statistical Book, Chapter Nine on Prices, Various Issues. - Central Agency for Public Mobilization and Statistics, Annual Bulletin of Prices of Foodstuffs and Products and Services (Producer - Wholesale - Consumer), Various Issues

**Table 12.** The results of logarithmic multiple regression analysis for the study variables during the period 2004-2021

| Variable | Coefficient | Std. Error | t-statistic | Prob |
|---|---|---|---|---|
| C | 0.033198 | 0.009010 | 3.684390 | 0.0028 |
| $DLOGX_3$ | 0.066418 | 0.027729 | 2.395288 | 0.0324 |
| $DLOGX_5$ | 0.045232 | 0.020645 | 2.190988 | 0.0473 |
| $DLOGX_7$ | -0.033531 | 0.013602 | -2.465127 | 0.0284 |
| R-squared | 0.638923 | Mean dependent var | 0.028843 | |
| Adjusted R-squared | 0.555598 | S.D. dependent var | 0.054604 | |
| S.E. of regression | 0.036401 | Akaike info criterion | -3.586129 | - |
| Sum squared resid | 0.017225 | Schwarz criterion | -3.390079 | |
| Log likelihood | 34.48210 | Hannan-Quinn critter | -3.566641 | |
| F-statistic | 7.667817 | Durbin-Watson stat | 1.881774 | |
| Prob(F-statistic) | 0.003353 | | - | |

Source. The results of data analysis in Table 11 by E-Views.

The results of the Unit Root Test1 (Appendix 1) showed that the values of the time series for all variables are not stationary at their level but are stable at their first differences, which means that they are integrated of the first degree I (1) during the period from 2004-2021.

The multiple regression was performed after ensuring the stability of the data at the first difference, and many attempts were made to obtain the best possible statistical estimates. The best functions were chosen according to the criteria of economic theory and statistical criteria, and the best was in the double logarithmic form, as shown in Table (12). The results of the analysis showed that the estimated model was acceptable from an economic and statistical point of view. It was found that the most important explanatory variables affecting the quantity of fish production from aquaculture in Egypt are the quantity of fish hatcheries production (Log X3), and the area of fish farms (Log X5 and the real value of fry (Log X7). The statistical significance of these variables was proven, and the value of $R^2$ indicated that the independent factors are responsible for about 56% of the changes occurring in the quantity of farmed fish production from aquaculture in Egypt, and the rest is due to other factors not measured by the model.

The model clearly indicates a direct relationship between the quantity of fish fry and fingerling production, the area of fish farms, and the quantity of fish produced from aquaculture. Increasing both the quantity of fry and the area of fish farms by 10% results in an increase in fish production by 0.66 and 0.45%, respectively. Conversely, there is an inverse relationship between the real value of fry and fish production from aquaculture. A 10% decrease in the real value of fry leads to a 0.34% increase in fish production from fish farming.

The dataset in the estimated model was tested for normality using the Jarque-Bera (JB) test, which reported a probability value of 0.1218, greater than 0.05. Therefore, the null hypothesis was accepted, indicating that the dataset is normally distributed. Regarding variance instability, the Breusch-Pagan test in Table (13) shows no evidence of variance instability, with a probability value of 0.7308, which is greater than 0.05. Additionally, the Godfrey-Pagan test

(Table 14) reported a probability value of 0.9742, also greater than 0.05, indicating no issues with autocorrelation. Thus, it can be concluded that the model is statistically acceptable.

**Table 13.** Breusch–Pagan test results to detect non-stationarity of variance

| | | | |
|---|---|---|---|
| F-statistic | 0.3568 | Prob. F(4,13) | 0.7852 |
| Obs*R-squared | 1.2931 | Prob. Chi-square(4) | 0.7308 |
| Scaled explained SS | 1.1489 | Prob. Chi-square(4) | 0.7653 |

**Table 14.** Godfrey- Pagan serial correlation LM

| | | | |
|---|---|---|---|
| F-statistic | 0.0007 | Prob. F(1,12) | 0.9788 |
| Obs*R-squared | 0.0010 | Prob. Chi-square(1) | 0.9742 |

## 6. The most important factors affecting the total quantity of fish consumption during the period from 2004-2021

The consumed quantity of a commodity affected by many economic and social factors, including individual income, commodity price, the prices of alternative and complementary goods, population number, consumer taste, customs and traditions, age, and gender. Some of these factors cannot be measured quantitatively, while others can be measured. Therefore, the relationship between the total quantity of fish consumption in thousand tons as a dependent variable (Y) and each independent variable was studied (Table 15), which were

| | |
|---|---|
| $\mathbf{X_1}$ Real retail price of poultry | LE/kg |
| $\mathbf{X_2}$ Real retail price of red meat | LE /kg |
| $\mathbf{X_3}$ Real retail price of tilapia | LE /kg |
| $\mathbf{X_4}$ Quantity of fish imports | thousand tons |
| $\mathbf{X_5}$ Total population of Egypt | million people |
| $\mathbf{X_6}$ Fish import price | LE/ thousand ton |
| $\mathbf{X_7}$ Average per capita share of gross national income at real price | thousand LE |

The results of the Unit Root Test1 (appendix 1) indicated that the values of the time series for all variables are not stable at their level but are stable at their first differences, which means that they are integrated of the first degree I (1) during the study period 2004-2021. Many attempts were made to obtain the best possible statistical estimates. The best functions was the multiple regression double logarithmic form (Table 16), the estimated model is acceptable from an economic and statistical perspective. The most important explanatory variables affecting the total quantity of fish consumption in Egypt were the real retail price of red meat (LogX2), the real retail price of tilapia (LogX3) and the quantity of fish imports (LogX4). The statistical significance of these variables was proven, and the ($R^2$) value indicates that independent factors are responsible for about 80% of the changes in total fish consumption in Egypt. The model showed that a 10% decrease in the real retail price of tilapia leads to an increase in the total quantity of fish consumption in Egypt by 0.895%, while there is a direct relationship between the real retail price of red meat and the quantity of fish imports and the total quantity of fish

consumption, as an increase in the real retail price of red meat (a substitute for fish) and the quantity of fish imports by 10% leads to an increase in the total quantity of fish consumption in Egypt by 3.2 and 1.96%, respectively.

The normal distribution of the residuals in the estimated model was tested by Jarque Bera (JB) test, the probability was 0.2507, which is greater than 0.05, hence the null hypothesis is accepted meaning that the residuals are normally distributed. For the problem of instability of variance, Table (17) shows that there was no problem of instability of variance because the estimated probability value was greater than 0.05 being 0.1298. For the problem of autocorrelation, the results of Godfrey- Pagan test showed that the probability value was greater than 0.05 being 0.6828 (Table 18), hence there are no errors in autocorrelation, and thus it can be said that the model is statistically acceptable.

**Table 15.** The most important factors affecting the total quantity of fish consumption in Egypt during the period from 2004-2021

| Item / Year | Fish consumption total quantity | current Poultry retail price | Real retail price of poultry | current red meat retail price | Real retail price of red meat | Current retail price of Tilapia | Real retail price of tilapia | Fish imports quantity | Total population of Egypt | Fish import price | Average per capita share of gross national income at current price | Average per capita share of gross national income at real price | average general index number for consumers prices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thousands ton | LE/kg | LE/kg | LE/kg | LE/kg | LE/kg | LE/kg | Thousands ton | Million people | Thousands LE/ton | Thousands LE | Thousands LE | Thousands LE |
| 2004 | 1064 | 8.07 | 13.99 | 24.51 | 42.48 | 10.02 | 17.37 | 204.00 | 74.17 | 2.97 | 6.53 | 11.31 | 57.7 |
| 2005 | 1075 | 7.30 | 12.16 | 26.86 | 44.73 | 8.61 | 14.34 | 188.50 | 75.52 | 2.78 | 7.11 | 11.84 | 60.1 |
| 2006 | 1173 | 8.37 | 12.96 | 29.37 | 45.46 | 9.50 | 14.71 | 206.00 | 76.87 | 2.84 | 8.07 | 12.50 | 64.6 |
| 2007 | 1225 | 8.61 | 12.08 | 32.85 | 46.11 | 10.86 | 15.24 | 220.80 | 78.23 | 4.23 | 9.61 | 13.48 | 71.3 |
| 2008 | 1151 | 11.94 | 14.04 | 36.26 | 42.63 | 10.86 | 12.77 | 104.60 | 79.64 | 19.05 | 11.34 | 13.33 | 85.1 |
| 2009 | 1264 | 12.02 | 12.67 | 40.48 | 42.68 | 12.01 | 12.66 | 147.00 | 81.13 | 17.65 | 12.86 | 13.55 | 94.9 |
| 2010 | 1481 | 14.62 | 13.87 | 53.73 | 50.98 | 12.26 | 11.63 | 183.10 | 82.76 | 15.19 | 14.29 | 13.56 | 105.4 |
| 2011 | 1526 | 16.63 | 14.28 | 58.60 | 50.32 | 14.02 | 12.04 | 175.00 | 84.53 | 17.75 | 15.80 | 13.57 | 116.5 |
| 2012 | 1605 | 20.36 | 16.28 | 62.90 | 50.30 | 17.34 | 13.87 | 249.00 | 86.42 | 19.15 | 18.93 | 15.14 | 125.1 |
| 2013 | 1635 | 22.63 | 16.39 | 67.15 | 48.64 | 20.32 | 14.72 | 202.80 | 88.40 | 14.67 | 20.50 | 14.85 | 138.1 |
| 2014 | 1704 | 24.92 | 16.39 | 77.94 | 51.26 | 31.03 | 20.41 | 244.30 | 90.42 | 16.53 | 23.00 | 15.12 | 152.1 |
| 2015 | 1707 | 24.50 | 14.56 | 86.69 | 51.52 | 22.78 | 13.54 | 204.20 | 92.44 | 21.07 | 25.98 | 15.44 | 168.3 |
| 2016 | 1828 | 27.92 | 14.49 | 97.67 | 50.67 | 23.81 | 12.35 | 220.40 | 94.45 | 21.77 | 28.30 | 14.68 | 192.8 |
| 2017 | 2130 | 32.92 | 13.06 | 139.33 | 55.28 | 31.58 | 12.53 | 339.10 | 96.44 | 29.75 | 35.28 | 14.00 | 252.1 |
| 2018 | 2290 | 30.58 | 10.64 | 148.32 | 51.61 | 28.77 | 10.01 | 386.10 | 98.42 | 25.00 | 43.95 | 15.29 | 287.4 |
| 2019 | 2563 | 29.30 | 9.40 | 144.31 | 46.28 | 33.42 | 10.72 | 555.00 | 100.39 | 27.21 | 51.09 | 16.38 | 311.8 |
| 2020 | 2583 | 27.80 | 8.48 | 132.94 | 40.55 | 32.94 | 10.05 | 600.30 | 102.33 | 19.36 | 55.44 | 16.91 | 327.8 |
| 2021 | 2228 | 30.94 | 8.92 | 137.51 | 39.62 | 30.19 | 8.70 | 323.29 | 104.26 | 30.18 | 58.95 | 16.99 | 347.0 |

Average annual general index number for consumers prices in rural and urban areas, with 2010 as the base year

The current retail price was converted to the real retail price using general consumer price index with 2010 as the base year

Average per capita of current national income was converted to real value using the average general consumer price index with 2010 as the base year.

Source collected and calculated from, Central Agency for Public Mobilization and Statistics, www.capmas.gov.eg - Central Agency for Public Mobilization and Statistics, Annual Bulletin of Prices of Foodstuffs and Products and Services (Producer-Wholesale-Consumer), Various Issues. - Central Agency for Public Mobilization and Statistics, Annual Bulletin of Production Movement, Foreign Trade and Available for Consumption of Agricultural Commodities, Various Issues. - Central Agency for Public Mobilization and Statistics, Statistical Yearbook, Chapter Nine on Prices, Various Issues. - World Bank Website, World Development Indicators, www.databank.wordbank.org

**Table 16.** Results of multiple logarithmic regression for the study variables during the period from 2004-2021

| Variable | Coefficient | Std. Error | t-Statistic | Prob |
|---|---|---|---|---|
| C | 0.019785 | 0.003560 | 5.558285 | 0.0001 |
| $DLOGX_3$ | 0.320176 | 0.110289 | 2.903060 | 0.0123 |
| $DLOGX_5$ | -0.089516 | 0.039197 | -2.283747 | 0.0398 |
| $DLOGX_7$ | 0.196032 | 0.028245 | 6.940347 | 0.0000 |
| R-squared | 0.839865 | Mean dependent var | 0.021527 | |
| Adjusted R-squared | 0.802911 | S.D. dependent var | 0.032907 | |
| S.E. of regression | 0.014609 | Akaike info criterion | -5.412034 | - |
| Sum squared resid. | 0.002774 | Schwarz criterion | -5.215984 | |
| Log likelihood | 50.00229 | Hannan-Quinn critter | -5.392546 | |
| F-statistic | 22.72716 | Durbin-Watson stat | 1.669349 | |
| Prob(F-statistic) | 0.000019 | - | | |

Source. Results of data analysis of Table (15) using E-Views program.

**Table 17.** Breusch–Pagan test results to detect non-stationarity of variance

| | | | |
|---|---|---|---|
| F-statistic | 2.1581 | Prob. F(4,13) | 0.1421 |
| Obs*R-squared | 5.6517 | Prob. Chi-square(4) | 0.1298 |
| Scaled explained SS | 4.8001 | Prob. Chi-square(4) | 0.1870 |

**Table 18.** Godfrey- Pagan serial Correlation LM

| | | | |
|---|---|---|---|
| F-statistic | 0.1190 | Prob. F(1,12) | 0.7360 |
| Obs*R-squared | 0.16700 | Prob. Chi-square(1) | 0.6828 |

## DISCUSSION

The increase in the quantity of local fish production can be attributed to policies aimed at expanding fish farming to meet the growing demand for fish, especially with the significant decrease in natural fishing production. Moreover, the increase in the quantity of exports may be attributed to the government's policy within the agricultural development strategy to cultivate new high-quality varieties of fish and export them at higher prices **(Sadek, 2022)**. Based on the aforementioned points, the reliance on domestic production to provide fish protein increased, consequently leading to a higher self-sufficiency ratio. Fish prices are affordable compared to red meat as a good source of animal protein; in addition, there are a lot of constraints hindering the expansion of animal and poultry production such as the high prices of feed ingredients and prevalence of certain diseases. Hence, fish can play important role in nutrition of a large segment of the world's population.

The lower percentages of fish production from natural fisheries are due to several factors, including overfishing, which has led to the collapse of entire fish stocks; violations of fishing cessation periods; destructive fishing methods; heavy pollution from sewage, industrial wastewater, and chemicals that have harmed fish health; accidents involving ships, which result in pollution that negatively impacts production; illegal, unreported, and unregulated fishing; excessive encroachment, such as filling and building large areas of lakes; neglect of lake maintenance, including the cleaning of straits; and inadequate enforcement of legislation, along with the absence of effective monitoring, control, and surveillance (MCS). All these factors have contributed to a significant decline in fish production. Recently, government efforts have been initiated to clean these lakes and remove excessive encroachment, which is likely to improve lake conditions and to increase fish production.

It is crucial to expand aquaculture practices, which only gained prominence in the early seventies, and implement the latest scientific methods for their dissemination and development. The optimal solution for improving nutritional levels and health standards lies in bridging the gap in individuals' consumption of animal proteins in general, and fish proteins in particular **(Abu Zeid, 2017)**.

Fish farm production can be increased by adopting modern management systems, including proper feeding and the use of high-quality fry and fingerlings. Fish farming intensity is often categorized based on the degree of control over the production process.

## RECOMMENDATIONS

1- Developing natural fisheries, increasing their efficiency, and removing obstacles that limit fish production, as they contribute only 26% of fish production in Egypt.
2- Increasing the number of licenses issued to fishermen, the number of mechanized fishing boats, protecting fishermen from the control of some wholesalers, and provide equipped means of transportation to maintain the quality of fish, as the research showed that increasing the number of fishermen and the number of mechanized fishing boats leads to an

increase in the quantity of fish production from natural fisheries by 0.5 and 0.21%, respectively.

3- Expanding the establishment of national fish farming projects is crucial, as they contribute approximately 74% of the total fish production in Egypt. The data also show that increasing both hatchery production and the area of fish farms leads to a rise in aquaculture production by 0.66% and 0.45%, respectively. Additionally, decreasing the cost of fry results in a 0.34% increase in fish production from aquaculture.
4- Develop and expand fish hatcheries, increase the area of fish farms, and promote intensive farming and fish cage systems, while utilizing modern technologies to maximize the benefits of water resources.
5- Establish training courses for fishermen on modern fishing techniques to enhance their skills, raise awareness about environmental issues, and promote sustainable fisheries management.

**Conflict of interest**

The authors have no conflicts of interest to declare.

**Availability of data**

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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**Authors' contributions**

A.M.M.A. El-Bana conceived the idea and performed the analytical calculations.
M.A.E. Salem contributed to the idea and design, and collected the research data.
Amal S. Omar wrote the manuscript.
Shahira M.M. El-Ganainy interpreted the results and contributed to writing the manuscript.
All authors discussed the results and contributed to the final manuscript.

## REFERENCES

**Abu Zeid, F.H.M. (2017).** An Analytical Study of the Economic and Administrative Systems of Aquaculture Projects in El-Fayoum Governorate, Master Thesis, Department of Agricultural Economics, Faculty of Agriculture, Fayoum University.

**CAPMAS,** Central Agency for Public Mobilization and Statistics, Fisheries Production Statistics Various Issues., www.capmas.gov.eg.

**El-Bana, A.M.M.A. (2016).** Economics of Aquaculture in Egypt in Light of Limited Production Resources, Department of Agricultural Economics, Faculty of Agriculture, Cairo University.

**El-Sayed, A.F.M.; Dickson, M.W. and El-Naggar, G.O. (2015).** Value chain analysis of the aquaculture feed sector in Egypt. Aquaculture, 437: 92–101.

**El-Seesy, S.M.M. (2006).** Aquaculture and its Role in Achieving Food Security, Egyptian Journal of Agricultural Economics, Vol. 16, No. 1, March 2006, pp. 185-212.

**FAO. (2016).** Fishery and Aquaculture Statistics Yearbook ,2016. Rome, Italy: Food and Agriculture organization of the United Nations. ISSN 2070-6057.

**GAFRD. (2012).** General authority for fish resources development. In: Fish Statistics Year Book. Cairo, Egypt: Ministry of Agriculture and Land Reclamation.

**LFRPDA. (2021).** Lakes and fish resources protection and development Agency, Fish Statistics Yearbook.

**MALR. (2022)** Ministry of Agriculture and Land Reclamation**,** Bulletin of Estimates Agricultural income year 2022. Economic Affairs Sector. Arab Republic of Egypt.

**Mehanna, S.F. (2022).** Egyptian marine fisheries and its sustainability, Egypt Sustainable fish production and processing. Fish Population Dynamics Lab, Fisheries Division, National Institute of Oceanography and Fisheries NIOF. https://www.researchgate.net/publication/355081159.

**Sadek, N.M.Y. (2022)** The Role of Agricultural Tenancy in Fish Production and Marketing in the Arab Republic of Egypt, PhD Thesis, Department of Agricultural Economics, Faculty of Agriculture, Cairo University.

**Shaalan, M.; El- Mahdy, M.; Saleh, M. and 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.

**Shaalana, M.; El- Mahdy, M.; Saleh, M. and El- Matbouli, M. (2017).** Aquaculture in Egypt: Insights on the Current Trends and Future Perspectives for Sustainable Development. Reviews in Fisheries Science & Aquaculture, DOI: 10.1080/23308249.2017.1358696.

**Soliman, I. and Amer, M. J. (2002).** An Analytical Study of Production, Consumption and Foreign Trade of Fishery Resources in Egypt, Al-Moasher Magazine, No. 464-466, 63rd Year, January 2002, pp. 367-368.

**Wang, Q.; Cheng, L.; Liu, J.; Li, Z.; Xie, S. and De Silva, S. S. (2015).** Freshwater aquaculture in PR China: Trends and prospects. Reviews in Fisheries Science & Aquaculture, 7(4): 283–302.

World Bank website, World Development Indicators **(www.databank.wordbank.org)**

**Appendix 1.** Results of the unit root test for total fish production, value, and the most important factors affecting the quantity of fish production from natural fisheries, fish farming, and the total quantity of fish consumption in Egypt, by using the Augmented Dickey-Fuller test.

| Variables | At level | | At first difference | | Result |
|---|---|---|---|---|---|
| | t-Statistic | Prob | t-Statistic | Prob | |
| Total quantity of fish production in Egypt | 3.773 | 0.999 n.s | -2.028 | 0.043** | I(1) |
| Total value of fish production | 4.353 | 0.999 n.s | -2.984 | 0.041** | I(1) |
| Fish production quantity from natural fisheries | 0.349 | 0.774 n.s | -5.394 | 0.001** | I(1) |
| Fishermen number | -0.703 | 0.397 n.s | -4.451 | 0.000** | I(1) |
| Mechanized fishing boats | 0.042 | 0.948 n.s | -2.012 | 0.041** | I(1) |
| Un-mechanized fishing boats | -2.219 | 0.207 n.s | -5.820 | 0.000** | I(1) |
| True price of tilapia fish | -0.487 | 0.489 n.s | -6.370 | 0.000** | I(1) |
| Fish imports quantity | -0.382 | 0.531 n.s | -3.579 | 0.002** | I(1) |
| True value of fuel, oil, and depreciation for fish boats | 2.101 | 0.988 n.s | -2.370 | 0.021** | I(1) |
| Quantity of farmed fish | 3.202 | 0.999 n.s | -2.217 | 0.029** | I(1) |
| The real product price of tilapia fish | -0.487 | 0.489 n.s | -6.370 | 0.000** | I(1) |
| Quantity of fish imports | -0.382 | 0.531 n.s | -3.579 | 0.002** | I(1) |
| Quantity of fish hatcheries production | 0.940 | 0.899 n.s | -2.151 | 0.034** | I(1) |
| Quantity of fry production from fry collection centers | -0.506 | 0.480 n.s | -6.439 | 0.000** | I(1) |
| The area of fish farms | 0.467 | 0.805 n.s | -2.773 | 0.009** | I(1) |
| The real value of fish feed | 0.474 | 0.807 n.s | -3.590 | 0.001** | I(1) |
| The real value of fry | -0.294 | 0.561 n.s | -6.753 | 0.000** | I(1) |
| Total quantity of fish consumption | 1.592 | 0.967 n.s | -2.649 | 0.022** | I(1) |
| Real retail price of poultry | -0.991 | 0.275 n.s | -4.731 | 0.009** | I(1) |
| Real retail price of red meat | -0.313 | 0.558 n.s | -3.662 | 0.042** | I(1) |
| Real retail price of tilapia | -1.180 | 0.208 n.s | -5.046 | 0.005** | I(1) |
| Quantity of fish imports | -0.382 | 0.531 n.s | -3.579 | 0.002** | I(1) |
| Total population of Egypt | 5.194 | 1.000 n.s | -3.907 | 0.039** | I(1) |
| Fish import price | 0.397 | 0.787 n.s | -5.104 | 0.005** | I(1) |
| Average per capita share of gross national income at real price | 1.960 | 0.984 n.s | -3.598 | 0.063** | I(1) |

Source: analysis results of Tables 1, 7, 11, 15, calculated using E-Views program.