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An Econometric Study of Marine Fish Farming: By Using the Simultaneous Equations Model

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Abstract: In Egypt, Fisheries is one of the most important sources of national income. The value of fish production was about 61.1 billion L.E in 2019, by annual increase rate by 26.5% compared by 2018. Also quantity of fish production was 2 million tons in 2019, by annual increase rate by 5.3% compared by 2018. Fish is an important source of food and can be relied upon to meet the continuous increase in the population's needs of animal protein as an alternative to other protein sources. Although the state possesses a large surface of water, but this is not sufficiently exploited. This led to the existence of a fish gap as a result of technical difficulties and some production and marketing problems. So that this study aimed to evaluate the productive activity of fish farming generally and marine fish farming particularly by studying and evaluating the most important factors that affect fish production and the inputs used for producing the most important marine species under the study which are: Gilthead sea bream, European sea bass, Mullet and Toubar fish. The study achieved that the relative importance of sources of the fish production according to its total production indicated to the importance of fish farming, as its production represented 74%, Followed by fish production from lakes, which represented 12%, Then the average of fish production from seas, which represented about 7.9%, Finally, the Nile River's production contributed by 5.25% of the average of total fish production during the study period, which was about 1513 thousand tons. In addition, Average of fish production from the governmental farms was about 10.36 thousand tons by an annual increase rate represented about 3.29%. The average of fish production from national farms was about 929.5 thousand tons by an annual increase rate represented about 7.59%. Average of fish production from condensed farms was about 2.59 thousand tons with an annual increase rate represented about 2.38%. Average of fish production from floating cages was about 179.2 thousand tons by an annual increase rate represented about 9.3%.
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Key words: Econometric, Marine, Simultaneous, Fish Farming.

Introduction

In Egypt, Fisheries is one of the most important sources of national income. It is also considered as a source of protein that provides the nutritional needs and develops other industries beside it. Sources of fish production are various according to their nature as seas, lakes, in addition fresh water which include the Nile River and its two branches, canals, drains and fish farms located in different parts of Egypt.

The value of fish production was about 61.1 billion L.E in 2019, by annual increase rate by 26.5% compared by 2018. Also quantity of fish production was 2 million tons in 2019, by annual increase rate by 5.3% compared by 2018. Fish farms got the largest share of fish production in 2019, as its production was 1.6 million tons, representing 79.7% of the total quantity of fish production in Egypt. Then lakes come in the second rank as its production was 220.7 thousand tons, representing 10.8%. Then marine water as its production was 99 thousand tons, representing 4.9%. In addition, fresh water produced about 77.4 thousand tons, representing 3.8%. Finally, rice fields produced 15.9 thousand tons, representing 0.8%.

The increase of quantities of fish production contributed in decrease of Egypt's imports of fish, whereas the value of Egyptian imports of fish were 841.9 million dollars in 2020, by annual decrease rate by 7% compared by 2019 as the value of Egyptian imports of fish were 905.1 million dollars. The state is striving to increase the quantity of fish production in the future to achieve self-sufficiency in producing fish whereas rate of fish self-sufficiency in 2019 was about 79.6%.

Research problem

In Egypt, There is a gap of animal protein because the local production of different types of meat, whether red or white cannot meet the increase of demand due to the increase in population from year to another. So that, the importance of fish production as a cheap source of animal protein is assisting to fill this growing gap.

Fish is an important source of food and can be relied upon to meet the continuous increase in the population's needs of animal protein as an alternative to other protein sources. Although the state possesses a large surface of water, but this is not sufficiently exploited. This led to the existence of a fish gap as a result of technical difficulties and some production and marketing problems.

These required to study and analyze the fish production in its most important sources of fish production. It assists the economic policy planners to develop programs that help developing fisheries and contributing to improve the Egyptian production of fish and increase its contribution in the agricultural domestic product.

Research objectives

This study aims to evaluate the productive activity of fish farming generally and marine fish farming particularly by studying the follow: -

- Evolution of fish production from its various sources in Egypt during the period 2008-2019.
- Estimating the most important economic and technical variables of fish in Egypt.
- Evolution of the production of the most important species of marine fish during the period 2008-2019.
- Studying and evaluating the most important factors that affect fish production and the inputs used for producing the most important marine species under the study which are: Gilthead sea bream, European sea bass, Mullet nei and Toubar fish.

Data sources and methodology

The research relied on descriptive analysis methods included averages, growth rates and quantitative analysis by using the simultaneous equations model, and estimating the functions of fish production for each species under study by using the three Stages least square method to identify the endogenous and exogenous variables affected the fish farming.

The simultaneous model under study consists of four structural equations. The first equation explains the most important factors affect the quantity of Gilthead sea bream fish production in the marine fish farm under study. The second equation shows the most important variables affect the quantity of European sea bass production in the marine fish farm under study. The third equation explains the most important factors that affect the quantity of mullet nei fish production in the marine fish farm under study. The fourth equation explained the most important factors affecting the quantity of toubar fish production in the marine fish farm under study. The mathematical form of the model can be explained as follows:

$$Y_1 = f(X_1, X_{21}, X_3, X_4, X_6, X_7, D_1, D_2, D_3, D_4)$$
$$Y_2 = f(X_1, X_{22}, X_3, X_4, X_7, D_1, D_2, D_4, D_5)$$
$$Y_3 = f(X_1, X_{23}, X_3, X_5, X_6, X_7, D_5)$$
$$Y_4 = f(X_1, X_{24}, X_3, X_4, X_5, X_6, X_7, D_1, D_2)$$

In order to avoid some estimation problems (such as the autocorrelation and multi-colinearity), so the study was estimated the coefficient of Durban Watson, the matrix of correlation coefficients.

Model specification

It is shown in table (1) and Figure (1) the specification of the simultaneous model under study for measuring the interaction effects of the most important endogenous (Yi) and exogenous (Xi) variables of fish production of marine fish farm under study.

Table (1) Specification of economic and technical variables in the econometric model

Variable	Type	
Y_1	Endogenous	Total quantity of Gilthead sea bream fish production by kilograms.
Y_2	Endogenous	Total quantity of European sea bass fish production by kilograms.
Y_3	Endogenous	Total quantity of Mullet nei fish production by kilograms.
Y_4	Endogenous	Total quantity of Tuobar fish production by kilograms.
X_1	Exogenous	Quantity of fodder by ton.
X_{21}	Exogenous	Number of Gilthead sea bream fry fish by thousand heads.
X_{22}	Exogenous	Number of European sea bass fry fish by thousand heads.
X_{23}	Exogenous	Number of Mullet nei fry fish by thousand heads.
X_{24}	Exogenous	Number of Tuobar fry fish by thousand heads.
X_3	exogenous	Number of Permanent employment.
X_4	exogenous	The area of the farm.
X_5	exogenous	Number of gates.
X_6	Exogenous	Number of nursery ponds in the farm
X_7	exogenous	Number of breeding ponds in the farm
D_1	exogenous	Dummy variable shows the difficulty of providing fry fishes and permit to purchase them in the suitable time, whereas if the answer is "no", it will equal "zero" but if the answer is "yes", it will equal "one".
D_2	exogenous	Dummy variable shows the bad roads leading to fish farm, whereas if the answer is "no", it will equal "zero" but if the answer is "yes", it will equal "one"."
D_3	exogenous	Dummy variable shows The unavailability of sources of electricity or fuel, whereas if the answer is "no", it will equal "zero" but if the answer is "yes", it will equal "one".
D_4	exogenous	Dummy variable shows the unavailability of salinity measuring devices, whereas if the answer is "no", it will equal "zero" but if the answer is "yes", it will equal "one".
D_5	exogenous	Dummy variable shows the unavailability of marine hatcheries, whereas if the answer is "no", it will equal "zero" but if the answer is "yes", it will equal "one".

The research will rely on two main sources of data: The first is the secondary data either published by the Ministry of Agriculture and Land Reclamation by its various sectors or unpublished data from the public Authority for Fisheries. The second is preliminary data that was collected through a specially designed questionnaire form through personal interviews with (90) owners of marine fish farms in the north coast region between Port Said and Damietta and along the coast between them. The personal interviews focused on collecting the most important productive, technical, economic and economic variables related to the items under study.

Identifiably of model's equations

Within the framework of the econometric approach, the equation included in a particular model can be identified on the basis of the number of variables that do not appear in that equation but appear in the rest of the model equations (Koutsoyiannis, 1981). In other words, the equation is just identified if we cannot form an equation similar to it through the algebraic operations of other equations in the model to include the same variables that appear in the consider equation (Taha et al. 1998). The rank condition can be used to determine model equations as follows: $(G – 1) > (k – M)$

Where:

G = Number of equations in the model (Number of internal variables).

K = Number of all variables in the model (internal and external variables).

M = Number of variables in the considered equation.

Results and discussion

First: Evolution of fish production from its various sources in Egypt

It is shown from data of table (2) the evolution of fish production in Egypt from its various sources during the period 2008-2019, which are included: Mediterranean Sea, Red sea, lakes, the River Nile, and fish farming. It was found that the average of fish production from the Mediterranean Sea and Red sea were about 113 thousand tons with an annual decrease rate about 2.63%. While the average fish production from lakes was about 177.4 thousand tons with an annual increase rate by about 2.83%. The average of fish production from the Nile was about 75.89 thousand tons with an annual increase rate by 0.08%. Finally, fish farming produces about 1513 thousand tons with an annual increase rate by 5.56% during the study period.

From the previous, there is an annual increase rate in fish production from lakes, fish farming, the

Nile River and its two branches but there is an annual decrease rate in fish production from the Mediterranean Sea and Red sea. The relative importance of sources of the fish production according to its total production indicated to the importance of fish farming, as its production represented 74%, Followed by fish production from lakes, which represented 12%, Then the average of fish production from seas, which represented about 7.9%, Finally, the Nile River's production contributed by 5.25% of the average of total fish production during the study period, which was about 1513 thousand tons.

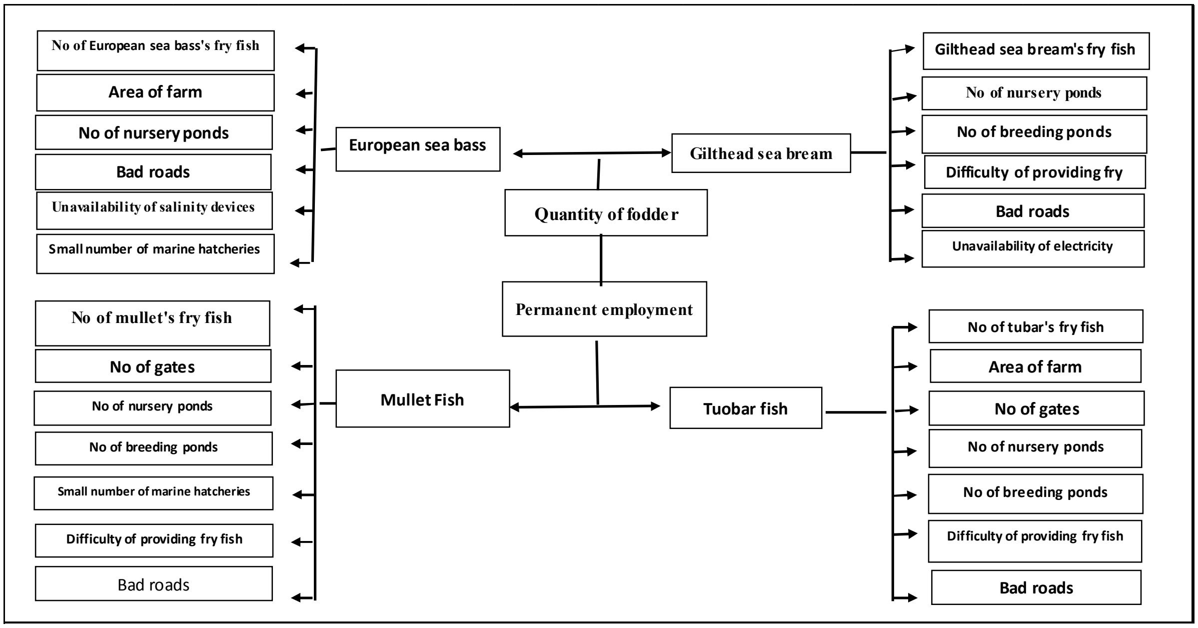

Figure (**1**) Specification of the simultaneous equations structural model of marine fish production.
Source: the equations of the simultaneous model by using data of sample.

Table (2) The relative importance of fish production by thousand tons from its various sources in Egypt during the period 2008 – 2019.

Years	Seas		Lakes		The River Nile & its branches		Fish Farming		Total production
	Thousand tons	%	Thousand tons	%	Thousand tons	%	Thousand tons	%	Thousand tons
2008	136.24	12.80	157.88	14.83	76.68	7.20	693.81	65.17	1064.6
2009	127.82	11.70	172.24	15.76	87.33	7.99	705.49	64.55	1092.9
2010	121.1	9.28	179.2	13.74	84.6	6.49	919.6	70.49	1304.5
2011	122.3	8.98	163.3	11.99	89.7	6.59	986.8	72.45	1362.1
2012	114.19	8.32	173.42	12.64	66.62	4.86	1017.74	74.18	1371.97
2013	106.66	7.33	182.53	12.55	67.67	4.65	1097.54	75.46	1454.4
2014	107.79	7.27	170.93	11.53	66.06	4.46	1137.09	76.73	1481.87
2015	102.93	6.78	171.48	11.29	69.71	4.59	1174.83	77.34	1518.95
2016	103.65	6.07	158.48	9.29	73.48	4.31	1370.66	80.33	1706.27
2017	109.76	6.02	183.46	10.06	77.73	4.26	1451.85	79.65	1822.8
2018	104.69	5.41	194.85	10.07	73.74	3.81	1561.45	80.71	1934.73
2019	98.95	4.85	220.713	10.82	77.376	3.79	1641.94	80.53	2039
Average	113.01	7.90	177.37	12.05	75.89	5.25	1146.57	74.80	1512.84
Growth rate	-2.63%	-	2.83%	-	0.08%	-	7.44%	-	5.56%

Source: Ministry of Agriculture and Land Reclamation, public Authority for Fisheries Development, Fish production statistics, various issues.

Second: Evolution of fish production from the Mediterranean Sea and Red sea

As it was shown from data in table (2) the evolution of fish production that produced from Mediterranean Sea and Red sea during the period 2008-2019. Fish production from the Mediterranean was about 48,000 tons in 2019, whereas its maximum value was about 88.9 thousand tons in 2008, and its annual average was about 66.1 thousand tons with an annual decrease rate represented about 5%. While the average of fish production from the Red Sea was about 46.9 thousand tons with an annual increase rate represented about 0.61% during the study period.

Table (2) The relative importance of fish production by thousand tons from the Mediterranean Sea and Red sea in Egypt during the period 2008 – 2019

Years	Mediterranean sea	%	Red sea	%	Total production
2008	88.882	65.24	47.361	34.76	136.24
2009	78.79	61.64	49.031	38.36	127.82
2010	77.388	63.90	43.974	36.31	121.1
2011	77.799	63.61	44.504	36.39	122.3
2012	69.332	60.72	44.866	39.29	114.19
2013	63.027	59.09	43.634	40.91	106.66
2014	62.746	58.21	45.053	41.80	107.79
2015	57.602	55.96	45.331	44.04	102.93
2016	53.964	52.06	49.69	47.94	103.65
2017	58.926	53.69	50.838	46.32	109.76
2018	56.73	54.19	47.965	45.82	104.69
2019	48.018	48.53	50.935	51.48	98.95
Average	66.10	-	46.93	-	113.01
Growth Rate	-5.00%	-	0.61%	-	-2.63%

Source: Ministry of Agriculture and Land Reclamation, public Authority for Fisheries Development, Fish production statistics, various issues.

Third: The evolution of fish production from fish farming and qualitative composition of the most important species.

Also it was shown from data in table (3) fish production from fish farming according to its various sources during the period 2008-2019, which are included: governmental farms, national farms, condensed fish farming, cages, and rice fields. Average of fish production from the governmental farms was about 10.36 thousand tons by an annual increase rate represented about 3.29%. The average of fish production from national farms was about 929.5 thousand tons by an annual increase rate represented about 7.59%. Average of fish production from condensed farms was about 2.59 thousand tons with an annual increase rate represented about 2.38%. Average of fish production from floating cages was about 179.2 thousand tons by an annual increase rate represented about 9.3%. Finally, average of fish production from rice fields was about 24.93 thousand tons by an annual decrease rate by about 4.6% during the study period.

Table (3): Fish production from fish farming by thousand tons in Egypt during period (2008 – 2018).

Years	Governmental Farms	%	National farms	%	Condensed farms	%	Floating cages	%	Rice field	%	Total production
2008	8.547	1.23	586.34	84.52	1.825	0.26	69.12	9.96	27.9	4.02	693.7
2009	6.605	0.94	591.28	83.81	1.86	0.26	68.05	9.65	37.7	5.34	705.5
2010	10.68	1.16	716.8	77.95	2.593	0.28	160.3	17.43	29.22	3.18	919.6
2011	10.1	1.02	721.68	73.13	3.815	0.39	216.1	21.90	35.2	3.57	986.9
2012	9.51	0.93	720.41	70.78	3.895	0.38	249.4	24.50	34.54	3.39	1017.8
2013	9.3	0.85	722.87	65.86	3.895	0.35	327.3	29.82	34.14	3.11	1097.5
2014	8.26	0.73	916.76	80.62	1.835	0.16	176.3	15.50	33.98	2.99	1137.1
2015	9.75	0.83	972.51	82.77	2.412	0.21	172.7	14.70	17.54	1.49	1174.9
2016	13.08	0.95	1166.18	85.08	2.268	0.17	175.6	12.81	13.54	0.99	1370.7
2017	12.2	0.84	1260.73	86.83	1.912	0.13	169.3	11.66	7.735	0.53	1451.9
2018	13.66	0.87	1368.31	87.63	2.324	0.15	165.4	10.59	11.79	0.76	1561.5
2019	12.61	0.77	1410.1	85.88	2.42	0.15	200.9	12.24	15.89	0.97	1641.9
Average	10.36	-	929.50	-	2.59	-	179.21	-	24.93	-	1146.6
Growth rate	3.29%	-	7.59%	-	2.38%	-	9.30%	-	-4.6%	-	7.44

Source: Ministry of Agriculture and Land Reclamation, public Authority for Fisheries Development, Fish production statistics, various issues.

Qualitative composition of some fish species produced from fish farming

As it was shown from table (4) the qualitative structure of the most important fish species produced from fish farming during the period 2008-2019, as Tilapia nei , Mullets nei, Carp, Gilthead sea bream, European sea bass, Meagre, catfishes, and Some other species like shrimps, Els nei, and Caranx spp. Average of tilapia production was about 755,000 tons by an annual increase rate by about 8.26%. The average of Mullets production was about 152,000 tons by an annual increase rate represented about 9%. Average of Carp production was about 175.64 thousand tons by an annual increase rate represented about 2.28%. While, the average of Gilthead sea bream production was about 20.25 thousand tons by an increase rate about 10%. Also average of European sea bass production was about 18.68 thousand tons by an annual increase represented 8.4%. Also, the average production of both Meagre and cat fishes were about 13.45 and 9.63 thousand tons respectively, by an annual increase rate represented about 10.5% and 2% respectively. Finally, average production of other species as shrimp, Els and Caranx had an annual decrease rate represented about 15% during the study period.

Table (4) Qualitative composition of some fish species produced from fish farming in Egypt during the period (2008-2019).

years	Tilapia	**%**	Mullets	**%**	Carp	**%**	Gilthead sea bream	**%**	European sea bass	**%**	Meagre	**%**	**Cat fishes**	**%**	**Others species***	**Total production**
2008	403.5	58.16	86.8	12.51	165.4	23.84	11.4	1.64	11.5	1.66	7.6	1.10	6.7	0.97	0.83	693.73
2009	411.5	58.33	85.7	12.15	165.2	23.42	12.3	1.74	12.7	1.80	9.5	1.35	7.4	1.05	1.20	705.5
2010	557.1	60.58	116.1	12.63	191.7	20.85	15.1	1.64	16.3	1.77	12.2	1.33	9.7	1.05	1.38	919.59
2011	610.6	61.87	114.1	11.56	203.6	20.63	14.1	1.43	17.7	1.79	12.1	1.23	13.1	1.33	1.59	986.90
2012	768.7	75.53	129.7	12.74	67.7	6.65	14.8	1.45	13.8	1.36	8.3	0.82	13.6	1.34	1.15	1017.76
2013	635.8	57.93	116.2	10.59	294.1	26.80	14.5	1.32	12.3	1.12	4.9	0.45	13.2	1.20	6.51	1097.51
2014	759.6	66.80	119.7	10.53	198.8	17.48	16.9	1.49	15.2	1.34	5.9	0.52	13.1	1.15	7.93	1137.14
2015	875.5	74.52	157.2	13.38	94.6	8.05	16.1	1.37	14.3	1.22	9.3	0.79	7.5	0.64	0.41	1174.91
2016	940.31	68.60	200.9	14.66	154.8	11.29	26.7	1.95	24.5	1.79	16.1	1.17	7.6	0.55	-0.24	1370.67
2017	967.3	66.62	210.2	14.48	174.2	12.00	35.2	2.42	30.7	2.11	25.1	1.73	8.3	0.57	0.88	1451.88
2018	1051.4	67.33	242.1	15.50	180.9	11.59	29.99	1.92	24.9	1.59	25.1	1.61	6.8	0.44	0.29	1561.48
2019	1081.2	65.85	243.9	14.85	216.7	13.20	35.9	2.19	30.3	1.85	25.3	1.54	8.5	0.52	0.12	1641.92
average	755.21	-	151.88	-	175.64	-	20.25	-	18.68	-	13.45	-	9.63	-	1.84	1146.58
Growth rate	8.56%	-	8.99%	-	2.28%	-	10.03%	-	8.41%	-	10.5%	-	2.00%	-	-15%	7.44%

Others species: Shrimps, Els and Caranx.

Source: Ministry of Agriculture and Land Reclamation, public Authority for Fisheries Development, Fish production statistics, various issues

Fourth: The economic and technical variables of fish production in Egypt

It was shown from data in table (5) the evolution of domestic production, national consumption, food gap self-sufficiency rate, and average of per capita share of fish by kilograms per a year during the period 2008-2018. The average of fish domestic production in Egypt was about 1,465 thousand tons, by an annual increase rate 5.55%. The average of fish national consumption was about 1734 thousand tons, with an annual increase rate 6.45%. The average of the fish food gap in Egypt was to about 268.5 thousand tons, with an annual increase rate represented 14% during the study period. It was found that the average of self-sufficiency rate of fish during the study period was about 85%, by an annual decrease rate 0.84%. As for the average of per capita share of fish by kilograms per a year was about 10.73 kilograms, by an annual increase rate represented about 2.07%, during the study period.

Table (5): Fish domestic production, national consumption, food gap by thousand tons, self-sufficiency, and average of per capita share of fish by kilograms per a year during the period 2008-2018.

Years	Domestic production (thousand tons)	National consumption (thousand tons)	Food gap (thousand tons)	Self-sufficiency rate (%)	Average of per capita share (kg)
2008	1068	1152	84	92.71	9.5
2009	1093	1233	140	88.65	9.7
2010	1305	1551	246	84.14	11.3
2011	1362	1533	171	88.85	11
2012	1372	1687	315	81.33	10.3
2013	1454	1666	212	87.27	9.9
2014	1482	2041	559	72.61	11.9
2015	1519	1795	276	84.62	10.2
2016	1706	1970	264	86.60	10.9
2017	1823	2154	331	84.63	11.4
2018	1935	2291	356	84.46	11.9
Average	1465.36	1733.91	268.55	85.08	10.73
Growth rate	5.55%	6.45%	14.03%	-0.84%	2.07%

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Food Balance Bulletin, Egypt, various issues.

Fifth: The evolution of the most important species of marine fish production

Data in table (6) showed the evolution of values and quantities of some marine fish species as: European sea bass, Mullets, Gilthead sea bream and Meagre during the study period 2008-2019. It was found that quantities and values of Mullets production got the first rank as the average quantity of Mullets production was about 195.86 thousand tons, by an annual increase rate was about 8%. Also, average value of Mullets production were 5.1 billion L.E, by an annual increase rate represented about 18% during the study period.

Also it was found that the average quantity of Gilthead sea bream production that produced from the Mediterranean sea, lakes and fish farms were about 23.34 thousand tons, with an annual increase rate represented 9.86% during the study period. While, the average value of Gilthead sea bream production was about 1.2 billion L.E, with an annual increase growth rate represented 22.12% during the study period. In addition, the average quantity of European sea bass production that produced from Mediterranean Sea, lakes and fish farms were about 20.77 thousand tons, by an annual increase rate 8.37% during the study period. Also, average value of European sea bass production was about 904.37 million L.E, with an annual increase rate represented 22.97% during the study period. It also was shown that average quantity of Meagre production was about 14.58 thousand tons, with an annual increase rate 13.63% during the study period. While, average value of Meagre production were about 578.01 million L.E, with an annual increase rate about 26.57% during the study period.

Sixth: Measuring the factors affect the production of marine fish

As it was showed from the data in table (7) the matrix of correlation coefficients between the endogenous and exogenous variables in the simultaneous model of the sample under the study was estimated in order to avoid falling into some estimation problems (such as multi-collinearity).It was found that there is a strong direct relationship (greater than 0.5) between the total quantities of Gilthead sea bream and Tuobar production. However, there was a weak inverse relationship (less than 0.3) between the total quantity of Mullets and European sea bass production.

It was also illustrated that there was a strong direct relationship between the production quantity of Gilthead sea bream fish and each of: the quantity of fodder, number of permanent employment, area of the farm and the number of breeding ponds in the farm. It was also showed that there was a strong direct relationship between the production quantities of European sea bass with each of: the quantity of fodder, number of permanent employment and the area of the farm. In addition, it was found that there was a strong direct relationship between the production quantities of Tuobar fish with the number of Tuobar fry fish. However, there is an inverse relationship between the production quantity of each Gilthead sea bream, European sea bass and Toubar with the dummy variables that showed the difficulty of providing the fry fishes and permitted to purchase them in the suitable time, bad roads leading to fish farms, the unavailability of sources of electricity or fuel, the unavailability of salinity measuring devices and the unavailability of marine hatcheries.

It was also found that there was a strong direct relationship between the quantities of fodder with each of: number of permanent employment, area of the farm and the number of nursery ponds in the farm. Also, there was a strong direct relationship between the numbers of breeding ponds with both number of permanent employment and area of the farm. While there were an inverse relationships between numbers of fry Gilthead sea bream with both number of fries of Mullets, toubar and the number of gates.

Table (6) The evolution of production quantities and values of the most important species of fish from marine fish production in Egypt during the period 2008-2019

	Mullets		Gilthead sea bream		European sea bass		Meagre	
Year	Quantity (Ton)	Value (Thousand L.E)	Quantity (Ton)	Value (Thousand L.E)	Quantity (Ton)	Value (Thousand L.E)	Quantity (Ton)	Value (Thousand L.E)
2009	231887	3795990	8133	283354	8199	155781	3421	54736
2010	147594	234379	17137	610591	18089	382040	13243	251617
2011	137543	2750860	15857	505521	19027	418404	12831	282282
2012	163176	3153926	16469	569251	15228	368670	10773	253166
2013	158579	2846493	16040	60583	13074	326031	5582	131177
2014	152499	3287857	18424	928201	16447	494561	6559	196770
2015	188549	3734935	16917	830907	15682	698326	9888	316416
2016	182979	4557311	27579	1700797	25681	1181326	17081	563673
2017	245852	8066404	36153	2390798	31897	1694050	25876	1267665
2018	279405	10066962	31799	2305110	26733	1567623	26344	1317200
Average	195863	5101984	23340.14	1255092	20677.4	904370	14586.1	578010
Growth rate	7.99%	18.03%	9.86%	22.12%	8.37%	22.97%	13.63%	26.57%

Source: Ministry of Agriculture and Land Reclamation, public Authority for Fisheries Development, Fish production statistics, various issues.

Table (7) Matrix of correlation coefficient between endogenous and exogenous variables in the simultaneous model.

	Y1	Y2	Y3	Y4	X1	X21	X22	X23	X24	X3	X4	X5	X6	X7	D1	D2	D3	D4	D5
Y1	1.00																		
Y2	0.26	1.00																	
Y3	0.43	-0.18	1.00																
Y4	0.66	0.03	0.26	1.00															
X1	0.59	0.63	0.10	0.33	1.00														
X21	0.17	0.00	-0.10	-0.18	0.10	1.00													
X22	0.10	0.43	-0.17	-0.20	0.39	0.25	1.00												
X23	0.24	0.09	0.35	0.16	0.20	-0.10	0.29	1.00											
X24	0.39	-0.14	0.42	0.69	0.06	-0.24	-0.25	0.23	1.00										
X3	0.59	0.52	0.21	0.29	0.70	0.01	0.06	0.22	0.32	1.00									
X4	0.60	0.52	0.15	0.39	0.76	0.23	0.18	-0.12	0.21	0.65	1.00								
X5	0.14	-0.05	0.23	0.22	0.32	-0.16	-0.22	-0.07	0.17	0.12	0.31	1.00							
X6	0.44	0.13	0.29	0.35	0.61	0.01	0.03	0.02	0.04	0.37	0.47	0.26	1.00						
X7	0.57	-0.01	0.30	0.49	0.39	0.21	-0.16	0.16	0.42	0.60	0.56	0.13	0.36	1.00					
D1	-0.16	-0.14	0.03	-0.04	-0.08	0.01	-0.11	-0.18	0.02	-0.12	0.04	0.02	0.08	0.03	1.00				
D2	-0.07	-0.08	0.15	0.00	-0.07	-0.09	-0.14	-0.05	0.09	-0.12	-0.02	0.08	0.03	-0.07	0.39	1.00			
D3	-0.05	-0.01	0.02	-0.04	-0.01	0.06	-0.05	0.05	0.00	-0.08	0.01	0.11	0.06	0.04	0.19	0.64	1.00		
D4	-0.02	-0.12	0.12	-0.09	-0.06	0.03	-0.10	0.04	0.02	-0.08	-0.02	0.14	0.00	0.05	0.23	0.59	0.61	1.00	
D5	-0.11	-0.09	-0.01	-0.03	-0.01	0.04	-0.20	-0.12	0.02	0.04	0.06	-0.04	0.16	0.14	0.11	0.30	0.33	0.41	1.00

Source: collected and calculated from the sample data.

Factors affect the total quantity of fish production in the sample

The first equation:

Factors affect the total quantity of Gilthead sea bream's production.

As it was shown from data in table(8) that the most important factors that affect the total quantity of Gilthead sea bream production are: quantity of fodder, number of Gilthead sea bream's fry fish, permanent employment in the farm, area of the farm, the number of nursery ponds, number of breeding ponds in the farm, dummy variables that showed the difficulty of providing fry fish and permits to purchase them in a suitable time, the bad condition of the roads leading to the fish farms, the unavailability of sources of electricity or fuel, and the unavailability of salinity measuring devices. The coefficient of determination was about 0.5436, which indicated that the variables under study explain about 54.36% of the change in the production quantity of Gilthead sea bream, and the rest is due to other factors are not included in the model.

There was a significant effect for each of: number of Gilthead sea bream's fry fish, number of breeding ponds in the farm, dummy variables that showed the difficulty of providing fry fish and the permission to purchase them at the suitable time and the dummy variable that showed the unavailability of salinity measuring devices, at the level of significance of 0.05.

It was also illustrated that there was a direct relationship between the production quantity of Gilthead sea bream and both of number of Gilthead sea bream's fry fish, and number of breeding ponds in the farm. Also it was found that there was an inverse relationship between the production quantity of Gilthead sea bream and each of: The difficulty of providing Gilthead sea bream's fry fish and permission to purchase them in a suitable time, and the unavailability of salinity measuring devices.

Data also indicated that the value of the response elasticity coefficient between the production quantity of Gilthead sea bream with each of: number of Gilthead sea bream's fry fish and the number of breeding ponds in the farm were about 0.29 and 0.41, respectively. So that, an increase in these factors by 10% leads to an increase in the production quantity of Gilthead sea bream by about 2.9% and 4.1%, respectively. While the value of the response elasticity coefficient between the production quantity of Gilthead sea bream with each of: Difficulty of providing Gilthead sea bream's fry fish or permission to purchase them at the right time, and the unavailability of salinity measuring devices, were about -0.12, -0.15, respectively, so that the increase of these factors by 10% leads to a decrease in the production quantity of Gilthead sea bream about 1.2% and 1.5%, respectively.

Table (8): Estimates of the parameters in the first equation in the econometric model: The most important factors affecting the production quantity of Gilthead sea bream in the sample.

Explanatory variables	parameters	value	t- calculated	Response elasticity
Constant	B_0	-342.44	-0.399	-0.08
Quantity of fodder (ton)	X1	107.79	1.37	0.29
Number of fry fish (thousand head)	X21	0.014	2.38	0.05
Permanent employment	X3	105.28	1.39	0.25
Farm area (feddan)	X4	14.852	0.49	0.07
Number of nursery ponds	X6	394.8	1.21	0.18
Number of breeding ponds	X7	624.73	2.81	0.41
Dummy variable reflected the difficulty of providing the fish fry.	D_1	-1071	-2.12	-0.12
Dummy variable reflected bad roads leading to fish farm.	D_2	330.87	0.45	0.06
Dummy variable reflected the unavailability of sources of electricity or fuel	D_3	285.07	0.45	0.05
Dummy variable reflected the unavailability of salinity devices.	D_4	-1038	-2.08	-0.15
Determination coefficient	R^2	0.5436	-	-
Durbin- Watson	D-W	1.732	-	-

Source: Collected and calculated from data of the sample during 2020, by using the SHAZAM.

The second equation: Factors affect the total quantity of European sea bass's production

As it was shown from data in table(8) that the most important factors that affect the total quantity of European sea bass production are: quantity of fodder, number of European sea bass's fry fish, permanent employment in the farm, area of the farm, the number of breeding ponds, dummy variables that showed the difficulty of providing European sea bass's fry fish and permits to purchase them in a suitable time, the bad condition of the roads leading to the fish farms, and the unavailability of salinity devices and the unavailability of marine hatcheries. The coefficient of determination was about 0.616, which indicated that the variables under study explain about 61.6% of the change in the production quantity of European sea bass, and the rest is due to other factors are not included in the model.

There was a significant effect in each of: number of European sea bass's fry fish, permanent employment in the farm, area of the farm, and the number of breeding ponds in the farm at the level of significance 0.05. As it was shown that there was a direct relationship between the production quantity of European sea bass and each of: number of European sea bass's fry fish, permanent employment in the farm, and the farm area. While it was found that there was an inverse relationship between the production quantity of European sea bass and the number of breeding ponds on the farm.

It was shown in table (9), the response elasticity coefficient between the production quantity of European sea bass and each of: number of European sea bass's fry fish, the permanent employment in the farm and the area of the farm were about 0.12, 1.59 and 1 respectively. That was, the increase of these factors by 10% led to an increase in the production quantity of European sea bass by about 1.2%, 15.9%, and 10%, respectively. While, the coefficient of response elasticity between the production quantities of European sea bass and numbers of breeding ponds were about -1.64. So that , when the number of breeding ponds increased by 10%, led to a decrease in the production quantity of European sea bass by about 16.4% in the sample of the study.

Table (9): Estimates of the parameters in the second equation in the econometric model: The most important factors affecting the production quantity of European sea bass in the sample.

Explanatory variables	Parameters	Value	t- Calculated	Response elasticity
Constant	B_0	-782.3	-1.15	-0.48
Quantity of fodder (ton)	X_1	49.56	0.85	0.38
Number of fry fish (thousand head)	X_{22}	0.036	2.76	0.12
Permanent employment	X_3	236.61	4.14	1.59
Farm area (feddan)	X_4	78.083	3.21	1.00
Number of breeding ponds	X_7	-910.39	-5.34	-1.64
Dummy variable reflected the difficulty of providing the fish fry.	D_1	-471.23	-1.14	-0.15
Dummy variable reflected bad roads leading to fish farm.	D_2	177.3	0.30	0.09
Dummy variable reflected the unavailability of salinity devices.	D_4	203.54	0.33	0.10
Dummy variable reflected the unavailability of marine hatcheries	D_5	-13.469	-0.03	-0.01
Determination coefficient	R^2	0.6163	-	-
Durbin- Watson	D-W	2.382	-	-

Source: Collected and calculated from data of the sample during 2020, by using the SHAZAM.

The third equation: Factors affect the total quantity of Mullet's production.

As it was shown in table (10) that the most important factors affected the total amount of Mullet production which were: the quantity of fodder, the number of mullet's fry fish, permanent employment, number of gates, number of nursery ponds, and number of breeding ponds on the farm, in addition to the dummy variable that showed the small number of marine hatcheries. The value of the coefficient of determination was 0.3515, which indicates that the variables under study explain about 35.15% of the change in the production quantity of mullet in the sample of the field study, and the rest is due to other factors not included in the model. There was a significant effect in each of: the quantity of fodder, the number of mullet's fry fish, the number of gates and the number of nursery ponds in the farm at a significant level of 0.05. As well as the presence of a direct relationship between the production quantity of mullet with each of: the number of mullet's fry fish, the number of gates and the number of nursery ponds in the farm. While, there was an inverse relationship between the production quantity of mullets and the quantity of fodder.

Data also indicated that the coefficient of response elasticity between the production of mullets and each of: the number of mullet's fry fish, the number of gates and the number of nursery ponds in the farm was about 0.24, 0.27 and 0.66 respectively. That is, the increase of these factors increased by 10% led to increase the production quantity of mullet by about 2.4%, 2.7% and 6.6% respectively. While the coefficient of response elasticity between the production quantity of mullet fish and the quantity of feed was about -0.81, so that the increase in the quantity of fodder by 10% led to decrease the production quantity of mullets by 8.1%.

Table (10): Estimates of the parameters in the third equation in the econometric model: The most important factors affecting the production quantity of mullet in the sample.

Explanatory variables	Parameters	Value	t- calculate	Response elasticity
Constant	B_0	575.49	0.493	0.11
Quantity of fodder (ton)	X_1	-330.83	-3.13	-0.81
Number of mullet's fry fish (thousand head)	X_{23}	0.14	3.79	0.24
Permanent employment	X_3	179.88	1.56	0.39
Numbers of gates	X_5	257.5	2.80	0.27
Number of nursery ponds	X_6	1571.6	3.12	0.66
Number of breeding ponds	X_7	395.09	1.24	0.23
Dummy variable reflected the unavailability of marine hatcheries	D_5	-665.95	-0.81	-0.09
Determination coefficient	R^2	0.3515	-	-
Durbin- Watson	D-W	1.546	-	-

Source: Collected and calculated from data of the sample during 2020, by using the SHAZAM.

The fourth equation: Factors affect the total quantity of tuobar's production

As it was shown in table (11) that the most important factors affecting the total quantity of tubar's production which were: the quantity of fodder, the number of tubar's fry fish, permanent employment, area of the farm, numbers of gates, number of nursery ponds, and number of breeding ponds on the farm, in addition to the dummy variable that showed the difficulty of providing the tubar's fish fry and bad roads leading to fish farm.

The value of the coefficient of determination was 0.6479, which indicates that the variables under study explain about 64.79% of the change in the production quantity of tubar fish in the sample of the field study, and the rest is due to other factors not included in the model.

There was a significant effect in each of: number of tubar's fry fish, permanent of employment, the number of nursery ponds, and the number of farm breeding ponds, at a significant level 0.05. Data also showed a positive relationship between the production quantity of tuobar and each of: the number of toubar's fry fish, the number of breeding ponds, and the number of farm breeding ponds. While, there was an inverse relationship between the production quantity of the toubar and the permanent employment.

The response elasticity coefficient between the production quantities of tuobar with each of: the number of toubar's fry fish, the number of breeding ponds, and the number of farm breeding ponds were about 0.69, 0.40 and 0.37, respectively. So that any increase of those factors by 10% lead to increase production quantity of tuobar by about 6.9%, 4%, 3.7% respectively. While, the response elasticity coefficient between the production quantity of tuobar with permanent employment at about - 0.65%. So that any increase in permanent employment by 10% led to a decrease in production quantity of tuobar by about 6.5% in the sample of the field study.

Table (11): Estimates of the parameters in the fourth equation in the econometric model: The most important factors affecting the production quantity of tuobar in the sample.

Explanatory variables	parameters	value	t- calculated	Response elasticity
Constant	B_0	-868.2	-1.32	-0.28
Quantity of fodder (ton)	X_1	104.56	1.69	0.41
Number of tuobar's fry fish (thousand head)	X_{24}	0.33	9.72	0.69
Permanent employment	X_3	-185.89	-3.17	-0.65
Farm area	X_4	22.51	0.93	0.15
Numbers of gates	X_5	11.08	0.26	0.02
Number of nursery ponds	X_6	591.86	2.44	0.40
Number of breeding ponds	X_7	392.25	2.28	0.37
Dummy variable reflected the difficulty of providing the fish fry.	D_1	-543.96	-1.33	-0.09
Dummy variable reflected bad roads leading to fish farm.	D_2	-133.05	-0.27	-0.03
Determination coefficient	R^2	0.6479	-	-
Durbin- Watson	D-W	2.01	-	-

Source: Collected and calculated from data of the sample during 2020, by using the SHAZAM.

Conclusion and Recommendations:

In Egypt, Fisheries is one of the most important sources of national income. The value of fish production was about 61.1 billion L.E in 2019, by annual increase rate by 26.5% compared by 2018. Also quantity of fish production was 2 million tons in 2019, by annual increase rate by 5.3% compared by 2018.

Fish is an important source of food and can be relied upon to meet the continuous increase in the population's needs of animal protein as an alternative to other protein sources. Although the state possesses a large surface of water, but this is not sufficiently exploited. This led to the existence of a fish gap as a result of technical difficulties and some production and marketing problems.

These required to study and analyze the fish production in its most important sources of fish production.

So that this study aimed to evaluate the productive activity of fish farming generally and marine fish farming particularly by studying and evaluating the most important factors that affect fish production and the inputs used for producing the most important marine species under the study which are: Gilthead sea bream, European sea bass, Mullet and Toubar fish.

The research relied on descriptive analysis methods included averages, growth rates and quantitative analysis by using the simultaneous equations model, and estimating the functions of fish production for each species under study by using the three Stages least square method to identify the endogenous and exogenous variables affected the fish farming by using preliminary data that was collected through a specially designed questionnaire form through personal interviews with (90) owners of marine fish farms in the north coast region between Port Said and Damietta and along the coast between them. The personal interviews focused on collecting the most important productive, technical, economic and economic variables related to the items under study.

The study reached to the most important results as follow:

1- The relative importance of sources of the fish production according to its total production indicated to the importance of fish farming, as its production represented 74%, Followed by fish production from lakes, which represented 12%, Then the average of fish production from seas, which represented about 7.9%, Finally, the Nile River's production contributed by 5.25% of the average of total fish production during the study period, which was about 1513 thousand tons.
2- Average of fish production from the governmental farms was about 10.36 thousand tons by an annual

increase rate represented about 3.29%. The average of fish production from national farms was about 929.5 thousand tons by an annual increase rate represented about 7.59%. Average of fish production from condensed farms was about 2.59 thousand tons with an annual increase rate represented about 2.38%. Average of fish production from floating cages was about 179.2 thousand tons by an annual increase rate represented about 9.3%.

3- The average of fish domestic production in Egypt was about 1,465 thousand tons, by an annual increase rate 5.55%. The average of fish national consumption was about 1734 thousand tons, with an annual increase rate 6.45%. The average of the fish food gap in Egypt was to about 268.5 thousand tons, with an annual increase rate represented 14%. So that the average of self-sufficiency rate of fish during the study period was about 85%, by an annual decrease rate 0.84%. As for the average of per capita share of fish by kilograms per a year was about 10.73 kilograms, by an annual increase rate represented about 2.07%, during the study period.

4- It was also illustrated that there was a direct relationship between the production quantity of Gilthead sea bream and both of number of Gilthead sea bream's fry fish, and number of breeding ponds in the farm. Also it was found that there was an inverse relationship between the production quantity of Gilthead sea bream and each of: The difficulty of providing Gilthead sea bream's fry fish and permission to purchase them in a suitable time, and the unavailability of salinity measuring devices.

5- There was a significant effect in each of: number of European sea bass's fry fish, permanent employment in the farm, area of the farm, and the number of breeding ponds in the farm at the level of significance 0.05. As it was shown that there was a direct relationship between the production quantity of European sea bass and each of: number of European sea bass's fry fish, permanent employment in the farm, and the farm area. While it was found that there was an inverse relationship between the production quantity of European sea bass and the number of breeding ponds on the farm.

6- Data also indicated that the coefficient of response elasticity between the production of mullets and each of: the number of mullet's fry fish , the number of gates and the number of nursery ponds in the farm was about 0.24, 0.27 and 0.66 respectively. That is, the increase of these factors increased by 10% led to increase the production quantity of mullet by about 2.4%, 2.7% and 6.6% respectively. While the coefficient of response elasticity between the production quantity of mullet fish and the quantity of feed was about -0.81, so that the increase in the quantity of fodder by 10% led to decrease the production quantity of mullets by 8.1%.

7- There was a significant effect in each of: number of tubar's fry fish, permanent of employment, the number of nursery ponds, and the number of farm breeding ponds, at a significant level 0.05. Data also showed a positive relationship between the production quantity of tuobar and each of: the number of toubar's fry fish, the number of breeding ponds, and the number of farm breeding ponds. While, there was an inverse relationship between the production quantity of the toubar and the permanent employment.

From the previous, this study recommended the follow:

1- The necessity of expanding fish farming projects because of its importance in reducing the fish gap.
2- It's necessary to educate fishermen not to catch fry fishes due to the attack of the fish stock.
3- Activating the role of agricultural extension in the field of fish farming by transferring the results of scientific research to the field through the extension agents. In addition to the application of modern and improved methods through assistance and provide advice to farmers and workers in the field of fish farming.
4- Providing loans at an appropriate interest rate and adequate guarantees for the owners of fish farms for developing the sector through expansion of investment or the application of technological methods and modern production systems.
5- Manufacturing of fishing supplies locally (ships - boats - engines - devices - tools and equipment ... etc.) for reducing customs duties on production requirements needed in the fishing sector, such as nets, hooks, and internal and external marine motors needed for fishing boats.

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