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Analytical Study of the Current and the Future Situation of Fishery Resources in Qaroun and Al-Rayyan Lakes in Fayoum Governorate, Egypt.

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ABSTRACT

The main objective of this work is identifying both the status and the future situation of fishery resources in Qaroun and Al-Rayyan lakes through the study of the chronological development of fish production and the most important economic and environmental factors affecting the fish production in these fisheries during the period (1995- 2015). Moreover, estimating the Maximum Sustainable Production, the Allowed Maximum Fishing Limit Rate to achieve equilibrium between production and fishing rates. Also, for studying of the most important economic and environmental factors, which affect the fish production from Qaroun and Al-Rayyan Lakes for the capability of achieving production efficiency within those fisheries, and predication the fish production of those fisheries within the period (2020-2025). The most significant results concluded by the study were as follows:

The fish production of Qaroun and Al-Rayyan Lakes have increased with a statistically annual rate of about 7.7%, 8.7% respectively, through the period of the study. The production surplus application model (Schaefer) results showed that within the period (1995-2015), the Maximum Sustainable Production (MSY) in Qaroun and Al-Rayyan Lakes had reached 3653.59 and 2369.23 tons per year, respectively by fishing effort, which reached about 343 and 127 fishing boats respectively. Moreover, the research has shown an increase in the actual production volume more than the Maximum Sustainable Production within the period of the study in Qaroun and Al-Rayyan Lakes and that the actual fishing effort exceeds the optimum fishing effort in these lakes, which explains how these Lakes are suffering from the phenomena of Illegal Fishing Activities.

-The total productivity of Lake Qaroun reached about (-1.91) and about(-0.253) in Al-Rayyan lakes, which indicate that the fish production in these lakes is in the third stage; uneconomic stage. In addition, these results concurred with many studies that confirmed the contamination of the lake's water with chemicals and pesticides due to the industrial, agricultural and sanitary sewage.

Finaly, it turned out that the expected volume of fish production in Qaroun Lake for the year 2020 and 2025 will be about 2992.7, 3676.4 tons respectively, with an increase of 21%, 48.6% than the average fish production within the period (1995-2015). The expected fish production in Al-Rayyan lakes is about 5352.52, 6597.31 tons for the years 2020 and 2025, respectively with 17.92 %, 23.3% increase than the fish production of the year 2015.

INTRODUCTION

The fishery resources represent a major significance addition for the national economy, as it is one of the main components of the agricultural sector, which are considered the main source of the national income, whereas the total agricultural net income reached 223.7 billion pounds in 2015; about 21.2 billion pounds has been

contributed by the fishery production alone with a percentage of 9.47% of the total agricultural net income.

Qaroun Lake is considered as one of the oldest natural lakes in the world and one of the inland lakes as well. Furthermore, it is one of the closed disconnected lakes from the sea and its area is measured by about 55 thousand acres and was used as a storage for the Nile water, and a main source of freshwater fish. When it has been disconnected from the River Nile, agriculture wastewater and sanitary sewer water through Al-batts and Al-wadi sewages became its supplier alongside with 12 other sub-sewages. Qaroun Lake is supplied with about 69% of agricultural sewer water and about 31% of Al-Rayyan Lakes' agricultural sewer water which led to the contamination of these lakes and the increase of salinity in Qaroun Lake, where it reached about 39 gram/litre in 2016. As for Al-Rayyan Valley Lakes, they lie in the Western Desert, 25km south of Fayoum City. Besides, the beginning of Al-Rayyan Valley project was in October 1968 after the water level increased in Qaroun Lake and was finished in January 1973 and it is a 9.5 km long canal that starts from the farthest parts of the governorate until it reaches the desert's borders then another 5 km long, 3 m wide covered canal at Al-boqyrat Hill which flows in the upper lake that measures about 65km after that through three natural waterfalls to the lower lake whose area is about 100km; on top of that, Al-Rayyan water is considered semi-fresh, with 20 g/l of salinity in the third lake and most of its production is Nile Fish except mullets and Sea bass as they were moved into other lakes as fingerlings that are being brought from Egypt's coastal marines.

Research Problem:

Nutrition is one of the most challenging problems that face the Egyptian economy since the 90s of the 20th century due the large gap between the production and consumption of animal protein, which is considered the cornerstone of nutritional elements that the human needs, and the animal protein which comes from the fish is considered a low price source compared to other animal protein products even in the current higher prices. Despite the diversity and expansion of fish production fisheries in Qaroun Lakes and Al-Rayan Valley, its relative importance in fish production in Fayoum Governorate has decreased from 40.8%, 35.5% of the total production in the governorate in 1995 which is estimated with about 1721 tons, to 6.1% and 24.6% in 2015[(10)] which is estimated with about 18419 tons consecutively and the reason for production efficiency drop in those fisheries is the absence of intact scientific management for utilizing these fisheries and being abused by illegal fishing activities.

Aims of the study:

The research aims mainly to study the current and the future situation of fisheries in Qaroun and Al-Rayyan Lakes through the following sub-objectives:

1- The study of the general trendof fish production volume in Qaroun and Al-Rayyan Lakes and the most important economic and environmental factors, which affect the fish production in these lakes duringh the period (1995- 2015).

2- Estimating of the Maximum Sustainable Production and the Allowed Maximum Fishing Rate in order to achieve equilibrium between production and fishing rates.

3- Prediction of the fish production of these lakes during the period (2020-2025).

MATERIALS AND METHODS

This research relied on the method of Economic Analysis to achieve its objectives, especially when the Exponential Model was estimated to calculate the annual growth rate for both fish production volume and the most important economic

and environmental variables which determine the volume of fish production in Qaroun and Al-Rayyan Valley Lakes' fisheries in Fayoum Governorate during the period (1995-2015); moreover, the production surplus model (Schaefer 1957), which is the most convenient fishing rates estimating models for Egypt's database conditions, was used and it aims to preserve fisheries as natural resources, determine the optimum production volumes for the current fisheries' states, determine the convenient number of fishing units which protect the fisheries from depletion[(4)]. The model also relies on fishing unit's productivity as a function of fishing effort to estimate the allowed maximum fishing rate, based on the relation between production and fishing effort estimated in fishing units as follows [(11)]:

$$Y/E=a + bE$$

Where:

Y= Production. Fish production of the fishery being studied

E= Effort. Fishing effort estimated in fishing units' number

a, b= constants.

And by using the available production and fishing units data for the period (1995-2015), a,b were estimated according to Regression Analysis, where the production curve was obtained from the formula:

$$Y= aE +bE^2$$

And the curve reaches its peak at:

$$E= - a/2b$$

And by compensating E's value in the production function, we get the Maximum Sustainable Production which can be expressed using the following function:

$$\text{Maximum Sustainable Production= MSY= } -a^2 / 4b$$

Therefore, the fishing effort that leads the Maximum Sustainable Production can be obtained from this function:

$$E_{max}= -a/2b$$

Also, the function determined the production productivity of Qaroun and Al-Rayyan Valley Lakes which represents the relation between the fish production volume and various economic and environmental factors during the period (1995-2015), which affects this production according to the production theory's assumptions, the available data's nature and what's been included in the previous studies of this field. Also, one of the most significant factors is (X1) fingerlings (in millions), (X2) fishing boats, (X3) number of fishermen (X4) fish production days, (X5) the average wholesale price (one thousand pounds per ton), (X6) sewage water quantity (million m3), (X7) Salinity percentage in the lake (gram/liter).

As for the conclusion of the major determinants or impactful factors on fish production in Qaroun and Al-Rayyan Valley Lakes and arranging them according to their effectiveness, the Multiple Regression method was used, where the statistical relation between production (Y) (as a dependent variable) and the previous factors as independent variables was measured; the linear, semi logarithmic and double logarithmic formulas were also used to estimate the function as follows (4):

$Y= a + b_1X_1 +b_2 X_2……+b_7X_7$ ……(1)

$Y= \ln a +b_1 \ln X_1 +……+b_7 \ln X_7$ ……(2)

$\ln Y=\ln a +b_1 \ln X_1 +……+b_7\ln X_7$…… (3)

Where 'a' is the Function's Constant, $b_1…..b_7$ are the Regression Coefficients that determine the independent variables $X_1…….X_7$; these convenient formulas were chosen from an economic and statistical perspective according to the value of the Adjusted R2 (R^{-2}), test (F) for the function and test (t) for the Estimating Function's Parameters:

The physical production efficiency is estimated based on the production elasticity of the inputs with the estimated productivity function. The production elasticity coefficients of the EPXi production input are obtained according to the mathematical formula of the function as follows:

$EPX_i = b_i/(\bar{Y}/\dot{x}_i) = b_i\, \dot{x}_i/\bar{Y}$ Linear Function

$EPX_i = b_i/\bar{Y}$ Semi-logarithmic Function

$EPX_i = b_i$ Logarithmic Function

Where b_i is the production input determinant Regression coefficient, y is the production volume average, x_i is the input volume within the period besides using Exponential Smoothing Forecasting Formula for fish production prediction in these fisheries in the upcoming years, where it showed the superiority of (Brown) model according to the predictive accuracy test of the model.

$FY_{t+1} = FY_t + \alpha\,(AY_t - FY_t)$

Where : FY_{t+1} is the expected value of the variable for the year t+1 where 1,2 …23=t FY_t is the expected value for the year t, AY_t is the true value of the variable for the year t, α is the coefficient adjustment (coefficient constant) where $0 < \alpha < 1$

The research was based on the published data of the variables studied during the period (1995-2015) and obtained from the Central Agency for Public Mobilization and Statistics and the Fish Resources Development Authority, in addition to the use of some studies and research related to the subject of the study.

RESULTS

First , the current of fish production in the lakes of Fayoum Governorate:

Qaroun Lake:

Through studying the general trendof the fish production volume in Qaroun Lake fisheries during the period (1995 – 2015), Table (1) shows that the average fish production is estimated with about 2473.7 tons for the study period, fish production in the lake reached a maximum of 4518 tons, with an increase of 542.7% over fish production in 1995 as a base year, in which fish production reached a minimum of 703 tons; estimating the general trend Formula estimation for the fish production volume during the period (1995-2015), Table (2) shows that the double logarithmic form is the most convenient of all forms, as the function's results indicate that the fish production volume from Qaroun Lake fisheries increased at a statistical amount (see Table 2) in about 7.7% per year during the time of the study.

Table (1) shows the chronological development of the number of fishing boats in Lake Qaroun fisheries during the period (1995- 2015). The number of fishing boats in the lake reached about 534 as an average for the study period. The Table shows that the number of fishing boats reached a maximum of 597 with an increase of about 11.2% of fishing boats in 1995 as a base year, where the number of fishing boats was estimated at 537, while the number of fishing boats in the lowest level of fishing in the year 2014 was estimated at 425 with 20.8% less than the base year , as Table (1) shows the productivity of boats from the lake fisheries, which was estimated at 4.7 tons as an average for the study period, ranged from 1.3 tons as a minimum in 1995 and between 10.6 tons maximum in 2014.

Table 1: The Descriptive Analysis of Fish Production Development and the most important economic and environmental variables in Qaroun Lake fisheries during the period (1995-2015).

Variable	minimum	Maximum	average	Standard deviation	Variation coefficient %
Fish production in tons	703.0	4518.0	2473.7	1341.7	54.2
Fishing boats	425.0	597.0	533.7	39.3	7.4
Boat's average production/season	1.3	10.6	4.7	2.7	58.2
Fishermen	1970.0	5085.0	4083.6	790.6	19.4
Fishermen's production in tons	0.24	1.13	0.59	0.28	48.4
Fishing days/ season	200.0	283.0	228.3	22.6	9.9
Average daily production in tons	2.7	21.3	11.1	6.4	57.2
Salinity percentage gram/liter	33.1	37.3	35.3	1.0	2.9
Sewage water percentage (million cubic meter)	398.4	743.6	599.2	101.8	17.0
Wholesale price average (thousand pounds/tons)	7.1	26.1	14.9	5.8	39.2

Source: data was gathered and calculated from table (1)'s data in the appendix.

By studying the Chronological Trend Formula for fishing boats' numbers in Qaroun Lake fisheries during the study period, the research has shown that, in light of Table (2), the number of boats in Qaroun Lake fisheries has tended to decline at a statistically significant annual rate of about 0.7% annually during the study period, while the overall general trend formula of the productivity of fishing boats indicates that the productivity of fishing boats has increased at a statistically significant annual rate of 8.5% years during the study period.

Table 2: The fish production estimation General Trend Formulas and the most important economic and environmental variables in Qaroun Lake during (1995-2015)

Formulas	R^2	F	Annual Growth Rate	Variable
LnY_1 =6.08 + 0.077 T	0.60	28.6**	7.7	Fish production in tons
LnY_2 =6.36 – 0.007 T	0.35	10.3**	-0.7	Fishing boats
LnY_3 =0.44+ 0.085 T	0.67	38.6**	8.5	Boat's average production/season
LnY_4 =8.1+ 0.017 T	0.19	4.5*	1.7	Fishermen
LnY_5 = -1.33 + 0.062 T	0.63	31.9**	6.2	Fishermen's production in tons
LnY_6 =5.54 – 0.01 T	0.43	14.1**	-1.0	Fishing days/ season
LnY_7 =1.26 + 0.087 T	0.66	36.0**	8.7	Average daily production in tons
LnY_8 =3.57 – 0.004 T	0.01	0.12	-0.4	Salinity percentage gram/liter
LnY_9 =6.54 – 0.014 T	0.25	6.3*	-1.4	Sewage water percentage (million cubic meter)
LnY_{10} =1.97+ 0.06 T	0.92	227.1**	6.0	Wholesale price average (thousand pounds/tons)

Source: data was gathered and calculated from Table (1)'s data in the appendix

Also, by studying the general trend of fishermen numbers in Qaroun Lake during the period (1995-2015), the number of fishermen in the lake reached about 4083.6 fishermen, as an average for the study period; this number reached its maximum in 2005 to be 5085 with an increase of 158% more than the fishermen numbers in 1995 as a base year, in which the numbers of fishermen reached its lowest rate as 1970 fishermen; also, the fish production productivity was estimated from the Lake's fisheries at 0.59 tons as an average for the study period, where it varied between 0.24 tons minimum in 1996 and 1.13 tons maximum in 2014.

In addition, by studying the General Trend Formula of fishermen numbers during the study period, Table (2) shows that the numbers of fishermen in Qaroun Lake tended to grow with a statistically significant annual rate of about 1.7% yearly during the study period. Furthermore, the formula indicates that the fishermen's productivity tended to increase in a statistically significant annual rate of about 6.2% yearly during the study period. As for the fish productioning days in the fisheries of Qaroun Lake during the study period, it reached 228 days during the season as an average for the study period and the fish productioning days reached its maximum in 1996 of about 283 days with a growth of 7.2% more than the fishing days in 1995 as a base year, in which the fishing days were estimated at 246 days, while the fishing days in the Lake's fisheries reached its lowest in 2009, at about 200 days with a decrease of about 24.2% than the base year; also, the average daily production was estimated at 11.1 tons as an average for the study period, where it varied between 2.7 tons minimum in 1995 and 21.3 tons maximum in 2014. Moreover, by studying the formula for the fishing days during the study period, Table (2) shows that fishing days tended to decrease with a statistically significant annual rate of about 1.0% yearly during the study period. Also, the same formula for the daily production indicates that the daily production increased in a statistically significant annual rate of about 8.7% yearly during the study period.

As for the salinity quantity's development in Qaroun Lake fisheries during the study period, it reached about 35.3 gram/liter as an average of the study period; it reached its maximum in 2006 of about 37.3 gram/ liter with an increase estimated at 5.1% more than the salinity percentage in 1995 as a base year, where the salinity percentage was estimated back then at about 35.52 gram/liter, where it reached its lowest in Qaroun Lake in 2014 at about 33.1 gram/liter with a decrease of about 6.8% than the base year and by studying the General Chronological Development Formula for the salinity rate during the study period; the research has also shown that it tended to decrease with a statistically insignificant annual rate of about 0.4% yearly during the study period.

As for the sewage water quantity's development in Qaroun Lake during the study period, it reached about 599.2 million cubic meter as an average for the study period; its maximum in 2006 was of about 743.6 million cubic meter, with an increase of about 5.9% more than the percentage of the year 1995 as a base year, in which the sewage water quantity was estimated at about 702.35 million cubic meter, where it reached its minimum in 2015 of about 398.4 million cubic meter, with a decrease in 43.3% than the base year; also, by studying the General Chronological Development Formula of sewage water quantity during the study period, the research has shown that it tended to decrease with a statistically significant annual rate in about 1.4% yearly during the study period.

Also, by studying the average wholesale price of fish in Qaroun Lake fisheries during the study period, it reached about 14.9 thousand pounds/ton as an average for the study period and that the average wholesale price reached its maximum in 2014 at about 26.1 thousand pounds/ton with an increase of about 233.5 % more than the percentage of the year 1995 as a base year,which estimated the average wholesale price about 7.82 thousand pounds/ton ,where it reached its lowest in 1996 at about 7.1 thousand pounds/ton with a decrease in 9.5% than the base year. By studying the General Chronological Development Formula of the wholesale price average during the study period, the research has shown that it tended to increase with a statistically significant annual rate in about 6.0% yearly during the study period.

Al-Rayyan Valley Lakes:

By examining the General trend of fish production from Al-Rayyan Valley fisheries during the period (1995-2015), table (3) shows that the average fish production was estimated at 2030.9 tons as an average of the study period. Fish production in lakes reached a maximum of 4539 tons in 2015, with an increase of about 642.9% of fish production in 1995 as a base year, in which fish production reached a minimum of 611 tons ,and with the general Trend formula's estimation for the fish production volume in the lakes during the period (1995-2015), table(4) shows that the double logarithmic form is the most convenient formula, as the formula's results indicates that the fish production from Qarul Lake fisheries tended to increase with a statistically significant annual rate of 8.7% yearly during the study period.

Table (3) shows the Chronological Development of fishing boats in the Al-Rayyan Valley Lakes during the period (1995 - 2015). The average number of fishing boats in the lake was 173, and the number of fishing boats reached 206 in 1997, an increase of 19.1% The number of fishing vessels in 1995 was estimated to be about 173, while the number of fishing boats in 2000 was estimated to be about 140 with a decrease of 19.1% from the base year. Table 3 shows the productivity of boats from fisheries Al-Rayyan lakes, which were estimated at 12.1 tons as an average for the study period, ranging from 3.4 tons in 1996 to 31.3 Max in 2015. The table shows that the number of boats in the Al-Rayyan Lake fisheries have tended to decline at an annual rate that is statistically insignificant by about 0.5% annually during the study period, while the general Chronological trend formula for the productivity of fishing boats indicates that the productivity of fishing boats has increased at a statistically significant annual (Not annual rate) of 9.2% annually during the study period.

By studying the general trend of the fishermen numbers in Al-Rayyan Lakes' fisheries, fishermen in the lakes during the period (1995 - 2015) was estimated at 1826 fishermen as an average for the study period. The number of fishermen reached a maximum of 2200 fishermen in 2014 and 2015, an increase of 22.6% over the number of fishermen in 1995 as a base year and reached a minimum of 1409 fishermen in 1998 with a 21.5% decrease for the base year. The average fishery productivity in these fisheries was estimated at 1.1 tons, ranging from a minimum of 0.3 tons in 1995 to a maximum of 2.1 tons in 2015. According to the general time trend equation, the number of fishermen in the Al-Rayyan Lakes' fisheries increased at a statistically significant annual rate of 1.4% annually during the study period. The general time trend equation for fisherman productivity indicates that fisherman productivity has tended to increase at a statistically significant annual rate of 7.2% annually during the study period.

As for the number of fishing days in the Al Rayyan lakes during the study period, it was about 225 days during the season as an average for the study period. The number of days of fishing reached a maximum of 275 days in 2006, an increase of 17.5% compared to the number of fishing days in 1995 as a base year. Fishing days were about 234 days, while the lowest in the year 2010 was estimated at 185 days with a decrease of 20.9% for the base year. The average daily production was estimated at 9.4 tons as an average for the study period, from 2.6 tons in 1995 to 20.6 tons in 2015. The general Chronological trend formula of the number of fishing days during the study period indicates that the number of fishing days has tended to decrease at a statistically significant annual rate of about 1.1% annually during the study period. The general time trend equation for the average daily production indicates that daily production has increased at a statistically significant annual rate of 9.8% annually during the study period.

As for the development of the quantity of sewage water in the Al-Rayyan lakes during the study period, it reached about 230.6 million m^3 as an average for the study period. The quantity of sewage water reached a maximum of 266.4 million m3 in the year 1995, while the lowest quantity of wastewater in 2015 was about 180 million m^3 Of the base year with a decrease of 48% over a base year, and the study of the general Chronological Trend formula, the quantity of sewage water during the study period is shown to have tended to decrease at a statistically significant annual rate of about 1.0% annually during the study period.

By studying of the development of the average wholesale price of fish in Al-Rayyan lakes during the period of study, it reached about 10.0 thousand pounds/ ton as an average for the study period, and the average wholesale price reached a maximum of 17.1 thousand pounds / ton in 2015, an increase of 226% over 1995 as a base year. In which the average wholesale price reached a minimum of about 5.2 thousand pounds/ ton. The formula of the general Chronological Trend of the average wholesale price during the study period is shown to have increased at a statistically significant annual rate of 5.0% annually during the study period.

Table 3: a descriptive analysis of the development of fish production and the most important economic and environmental variables in Al-Rayyan lakes' fisheries during the period (1995-2015).

Variable	Minimum	Maximum	Average	Standard Deviation	Variation Coefficient %
Fish production in tons	611.0	4539.0	2030.9	1104.5	54.4
Fishing boats	140.0	206.0	173.1	19.3	11.2
Average Production of a single boat/season (ton)	3.4	31.3	12.1	7.1	58.8
Fishermen numbers	1409.0	2200.0	1825.9	218.2	11.9
Fisherman's average production in tons	0.3	2.1	1.1	٠.5	46.4
Fishing days / season	185.0	275.0	225.3	25.1	11.1
Average daily production in tons	2.6	20.6	9.4	5.6	59.2
Sewage water quantity	180.0	266.4	230.6	20.0	8.7
Wholesale price average (thousand pounds/ton)	5.2	17.1	10.0	3.5	34.7

Source: data was gathered and calculated from table (2)'s data in the appendix.

Table 4: Estimating fish production General Trend formulas and the most important economic and environmental variables in Al-Rayyan Lakes' fisheries during the period (1995-2015AD).

Variable	Annual growth rate %	F	R^2	Formulas
Fish production in tons	8.7	134.8**	0.88	$LnY_1 = 6.51+0.087\ T$
Fishing boats (per boat)	-0.5	1.6	0.11	$LnY_2 = 5.2 – 0.005\ T$
Boat's average production/ season in tons	9.2	90.9**	0.83	$LnY_3 =1.31+0.092\ T$
Fishermen numbers	1.4	22.0**	0.54	$LnY_4 =7.35+ 0.014T$
Fisherman's average production in tons	7.2	66.8**	0.78	$LnY_5 = –0.83 +0.072\ T$
Fishing days/ season	-1.1	11.4**	0.38	$LnY_6 = 5.53 – 0.011\ T$
Average daily production in tons	9.8	155.9**	0.89	$LnY_7 = 0.98 + 0.098\ T$
Sewage water quantity**	-1.0	16.9**	0.47	$LnY_8 = 5.55 – 0.01T$
Wholesale price average (thousand pounds/ton)	5.0	126.3**	0.87	$LnY_9 = 1.71 + 0.05\ T$

Source: data was gathered and calculated from table (2)'s data in the appendix.

Second: The results of the implementation of the Schaefer model on the fisheries of Qaroun and Al-rayan Lakes:

Qaroun Lake Fisheries:

In order to determine the extent of the fisheries of Qaroun Lake, the development of production and fishing units was monitored and analyzed in the Qaroun Lake fisheries. The results of the application of the surplus model of production (Schaefer) during the period 1995-2015 indicate that the Maximum Sustainable Production (MSY) reached 3653.59 Tons per year from a fishing effort of about 343 boats:

$Y = 21.3211 - 0.03111\ E$

(2.774)* (-2.165)*

$Emax = \frac{-a}{2b}$ =342.72 $MSY = \frac{-a^2}{4b}$ =3653.59 $R^2 = 0.20$ F=4.7*

When comparing the results obtained from the model with the status quo of the lake, the research has shown that the actual production exceeds the allowed Maximum Sustainable Production (MSY) during the last years of the study period, namely 2010, 2012, 2013, 2014, 6.8%, 19.4%, 20.7%, 21.0% and 23.7%, respectively, from a fishing effort of about 542, 529, 529, 512 and 423, respectively (58.1%,54.4%, 54.4%, 49.4% and 24.0%, respectively). Consequently, the extent of fishing in the Qaroun Lake is characterized by the phenomenon of illegal fishing practices, and therefore the fish stocks of the lake. The result is that the lake's fish production will decline in the following years.

Al-Rayyan Lake Fisheries:

The results of the application of the surplus model of production (Schaefer) during the period (1995-2015) have shown that the Maximum Sustainable Production (MSY) of Al-Rayyan Lake fisheries amounted to about 2369.23 tons per year from a fishing effort of about 127 boats.

$Y = 37.473 - 0.148\ E$

(3.26)** (-2.245)*

$Emax = \frac{-a}{2b}$ =126.45 $MSY = \frac{-a^2}{4b}$ =2369.23 $R^2 = 0.21$ F=5.0*

When comparing the results obtained from the model with the current situation of the Al-Rayyan lakes, it is clear that the actual production exceeds the allowed production volume (MSY) during the last seven years of the study period, namely 2009, 2010, 2011, 2012, 2013, 2014, 2015, 5.6%, 10.8%, 28.9%, 44.2%, 45.7%, 59.6% and 91.6% respectively, from a fishing effort of about 173, 175, 169, 187, 165, 170 and 145 respectively with an increase of over 36.2%, 37.8%, 33.1%, 47.2%, 29.9%, 33.9% and 14.2%, respectively. hence, it's obvious how Al-Rayyan Lakes' fisheries suffer from the increase of illegal fishing practices phenomena, especially after the fish production deterioration in Qaroun Lake and the coincide of Qaroun Lake closure with Lake Nasser's, that's because most of Lake Nasser's fishermen are from Fayoum's fishermen. Therefore, it is expected that the Lakes' fish stock will decline, resulting a fish production decrease in the following years.

Based on the above, it is clear that the fisheries of Lake Qaroun and Al-Rayyan suffer from an increase of the phenomenon of illegal fishing practices in recent years, which requires a re-planning of the fisheries' management.

Third: Estimation of the most important economic and environmental factors of the fish production in Qaroun and Al-Rayan lakes during the period (1995-2015).

The importance of determinant or impacting variables on the fish production of Qaroun and Al-Rayyan lakes lies in defining the sustainable management of the fisheries of these lakes, in order to determine the causes of the decline in fish production in these fisheries and therefore the possibility of raising fish production capacity through the development of a discipline system adapts automatically to any change in environmental conditions, because the decline or deterioration of the production capacity of fish to any fishery in general means that the utilization rates are higher than the rates of compensation for the fishery, resulting in a decrease in productivity and the extinction of certain species, the absence of growth, sustainable development and no biological balance [(3)].

The standard estimation of the fish production formula in Qaroun Lake fisheries:

The most important economic and environmental variables that can have an impact on fisheries production in Lake Qaroun (Y) can be identified during the period 1995-2015, where The Multiple Regression method was used in the linear, double logarithmic, and semi-logarithmic forms as in Table (5), where it was noticed that the double logarithmic formula was better and the most convenient one according to an economic and statistical point of view, based on the value of the R^{-2}, the (F) test of the function and the (t) test of the estimated function parameters. The results of model (3) indicate the significance of the estimated model at a significant level of 0.01, where the value of F is about 17.0, and the value of the Derbin-Watson test indicates that the model is free from the problem of autocorrelation; the explanatory factors under study were able to explain about 84.7% of the change in the dependent variable (the fish production of Lake Qaroun), where the coefficient of determination is 0.847. The estimated model has good efficiency in the representation of the data used in the estimation according to the efficiency models' indicators, majorly The Root Mean Square Error (RMSE) of 0.195, the Mean Absolute Error (MAE) of 0.16, the mean absolute percentage error (MAPE) of the 2.09% and the coefficient of inequality of (U – Theil), which was close to zero, and in the light of the Breusch- Godfrey Serial Correlation LM Test which refers to a Lagrange multiplier test of residuals (F), which is a statistically insignificant value at the probabilistic level of 1%, indicating that the estimating model of the autocorrelation problem is free of the residuals problem, as demonstrated by the Arch Test, which refers to the Lagrange multiplier test for variance in the series, the calculated value (F) of the test was 0.26, which is statistically insignificant at the probabilistic level of 1%, indicating that the estimated model has no autocorrelation in the series variation.

The results of the stepwise double logarithmic model (4) indicate the most important factors that may have an impact on fish production (Y), which are limited to the numbers of fingerlings (X_1), number of fishers (X_3), average wholesale price (X_5) and Salinity rate (X_7) ,The results of this model indicate that there is a positive relationship between the quantity of fish production in Qaroun Lake, the number of fingerlings, the number of fishermen and the average wholesale price, which is consistent with the economic logic, also the production elasticity of these elements was 0.30, 0.84, 1.03, respectively, indicating that the increase in the number of fingerlings in the lake, the number of fishermen and the average wholesale price by 10% (4) resulting an increase in the fish production in Qaroun Lake fisheries of 3.0%, 8.4%, 10.3% respectively; Moreover, model (4) indicates that there is an inverse relationship between the quantity of fish production in Qaroun Lake fisheries and the salinity variable in the lake, which is consistent with the economic logic, where it reached the value of the production elasticity of this element in about 4.08 indicating

that the increase of salinity in the lake by 10% will lead to a decrease of fish production by 40.8%. The total production elasticity of these elements with statistical effect is estimated at -1.91, indicating that fish production

In Qaroun Lake is in the third phase of the Law of Diminishing Returns, a non-economic stage where production is decreasing by the declining rate, and this result agreed with many of the studies that have confirmed the contamination of the lake's water quality and quantity by pesticides and chemicals as a result of the agricultural, health and industrial waste [5].

Table 5: The standard estimation of the most important economic and environmental factors affecting the fish production in Qaroun Lake and Al-Rayyan in Fayoum Governorate during the period 1995-2015.

Variables	Qaroun Lake				Al-Rayyan Lakes			
	The multiple linear model(1)	The semi-logarithmic model(2)	The double logarithmic model(3)	The stepwise double logarithmic model (4)	The double logarithmic model(5)	The semi-logarithmic model(6)	The multiple linear model(7)	The stepwise linear model (8)
Constant	3498.3	2403.33	6.19	11.81	15.00	14818.21	3566.63	2555.37
	(0.50)	(0.07)	(0.52)	(1.66)	(2.31)*	(1.73)	(2.53)*	(2.85)*
Fingerlings (X1)	21.72	424.62	0.24	0.30	0.01	-176.28	-14.56	---
	(0.73)	(1.17)	(1.73)	(3.16)**	(0.17)	(-2.02)	(-1.20)	---
(X_2) Boats	4.32	1017.88	0.34	---	-1.35	-1933.05	-11.23	-11.36
	(0.68)	(0.36)	(0.32)	---	(-3.02)**	(-3.27)**	(-3.5)**	(-3.79)**
(X_3)Fishermen	0.50	914.73	0.79	0.84	0.26	708.22	0.32	---
	(1.94)	(1.07)	(2.47)*	(3.18)**	(0.51)	(1.04)	(0.88)	---
Fishing days (X_4)	7.22	2284.763	0.377	---	-0.92	-1877.75	-7.09	-5.72
	(0.73)	(0.91)	(0.40)	---	(-1.87)	(-2.88)*	(-2.60)*	(-2.25)*
Wholesale price average (X_5)	209.6	3188.57	1.23	1.03	1.30	2347.64	236.06	272.73
	(3.67)**	(3.89)**	(4.01)**	(6.95)**	(5.92)**	(8.08)**	(8.78)**	(14.65)**
Sewage water (X_6) quantity	2.43	991.22	0.39	---	-0.09	-545.44	-3.63	---
	(1.12)	(0.83)	(0.89)	---	(-0.11)	(-0.50)	(-0.86)	---
	-337.01	-11795.1	-4.39	-4.08	---	---	---	---
	(-2.22)*	(-2.22)*	(-2.21)*	(-2.27)*	---	---	---	---
Salinity rate (X_7)	F=9.0** R^2=0.830 R^{-2} =0.740	F=10.4** R^2=0.849 R^{-2} =0.767	D.W=1.40 F=17.0** R^2=0.901 R^{-2} =0.847	F=30.8** R^2=0.885 R^{-2}=0.856	F =25.5** R^2 = 0.916 R^{-2} =0.88	F=56.8** R^2 =0.961 R^{-2} =0.944	D.W=1.64 F=64.7** R^2 =0.965 R^{-2} =0.950	F=120.3** R^2 =0.955 R^{-2} =0.947
Model's quality assurance tests and predictive ability			Breusch-Godfrey Serial Correlation LM Test: F =1.1 Prob.F(1,12)=0.30 ARCH Test F=0.26 Prob.F (1,18)=0.62 Root Mean Squared Error =0.165 Mean Absolute Error =0.158 Mean Abs. Percent Error=2.09 Theil inequality coefficient= 0.013				Breusch-Godfrey Serial Correlation LM Test: F =1.2 Prob.F(1,12)=0.18 ARCH Test:F=0.001 Prob.F(1,18)=0.97 Root Mean Squared Error =201.2 Mean Absolute Error =161.9 Mean Abs. Percent Error=11.6 Theil inequality coefficient= 0.04	

The values inside parenthesis are (T) statistically significant, *significant on 0.05's statistical level and** significant on 0.01's statistical level. Source: calculated from table (1), (2)'s data in the appendix.

Estimation of Fish Production Function in Al-Rayyan Lake Fisheries:

By determining the most important economic and environmental variables that can possibly affect the fish production in Al-Rayyan Lakes' fisheries (Y) during the period (1995-2015), as in Table (5) where it was noted that the linear formula was the best and most appropriate mathematical formula from an economic and statistical point of view, as the results of model (7) show the significance of the estimated model at a significant level of 0.01, with the value of (F) being about 47.9 as well as the value of the Derbin-Watson test (DW) indicates that the model is free from the

problem of autocorrelation and that the explanatory factors under study were able to explain about 95.0% of the variation in the dependent variable (fish production from Al-Rayyan Lake fisheries) where the coefficient of determination was 0.950. The estimated model has good efficiency in representing the data used in the estimation according to the efficiency indicators of the models, most importantly Root Mean Square Error (RMSE) of 201.2, the Mean Error Rate (MAE) of 161.9, the average rate of MAPE of 11.6% and the coefficient of inequality of U - Theil, which is rounded to zero and in light of the Breusch- Godfrey Serial test Correlation LM Test which indicates Lagrange multiplication test for autocorrelation in residuals (F) calculated for test 1.2, which is statistically insignificant at the probabilistic level of 1%, indicating that the estimating model has no autocorrelation problem in the series variation, as evidenced by the Arch Test, which indicates a multiplier test Lagrange for variance in the series showed that the calculated F value of the test was 0.001, which is statistically insignificant at the probabilistic level of 1%, indicating that the estimated model has no autocorrelation in the series variation. The results of the stepwise linear model (8) indicate the most important factors that can have an impact on fish production (Y), which are limited to the number of fishing boats (X_2), the number of fishing days during the season (X_4), the average wholesale price (X_5). The results of the model indicate that there is an inverse relationship between the amount of fish production in Al-Rayyan lakes' fisheries, the number of fishing boats and the number of days of fishing, where increase of these elements by one unit will lead to a decrease in fisheries production by 11.36 tons, 5.72 tons, Model (8) indicates a positive relationship between the amount of fish production in Al-Rayyan Lake fisheries and The average wholesale price, which is consistent with the economic logic, as the increase in the average wholesale price by 1000 pounds per ton will lead to an increase in fish production from Al-Rayyan fisheries by 272.72 tons. The production elasticity of the number of fishing boats, the number of fishing days, the quantity of sewage water and the average wholesale price were estimated at about -0.968,-0.635, 1.35 respectively, also the total elasticity is estimated at (-0.253), which indicates that fish production in Al-Rayyan fisheries is in the non-economic stage due to the excessive use of the number of fishing boats for the economic limit of fishing effort, which requires the necessity of working on reducing the number of boats; Moreover, the productivity flexibility of the number of fishing days during the season indicates the necessity of commitment not to practice fishing during periods of prohibition and to prevent illegal fishing in addition to the necessity of reducing the amount of sewage pouring into the lake which causes the contamination of water and raises water level in the waterfalls and the second lake which leads to the deterioration of fish production.

Fourth: Prediction of Fish Production of Qaroun and Al-Rayyan Lakes':

Forecasting Fish Production of Qaroun Lake:

Using the Exponential Smoothing Forecasting Method, where (Brown) model showed superiority according to model's forecasting accuracy tests.In addition, the statistical insignificance of the independent correlation coefficient (Ljung-Box) for the independent variables of the study indicates that there is no autocorrelation between the errors, in addition to the statistical significance of the (α) coefficient adjustment of the independent variables that affect the fish production in Qaroun Lake the most based on model (4), Table (5), which will be used to forecast the volume of fish production in the lake during the period (2020-2025). The value of the adjustment coefficient for the number of fingerlings (X_1, number of Fingerlings), (X_3,

number of fishers), (X_5, average wholesale price) and (X_7, salinity ratio) was about 0.23, 0.379, 0.01, 0.361 respectively.

Table 6: Expected values of fish production in Qaroun Lake's fisheries during the period (2020-2025)

Years	Forecast	UCL Upper Control Limit	LCL Lower Control Limit
2020	2992.66	10447.65	524.33
2021	3032.29	12394.93	330.89
2022	3117.11	14747.31	136.49
2023	3246.36	17614.53	6.92
2024	3431.18	21070.42	89.34
2025	3676.39	25223.22	373.07

Source: Calculated from table (3)'s data in the appendix and the estimating model in table (5).

The results of Table (3) in the appendix indicate that the expected value of the number of fingerlings (X_1) in 2025 was about 6.88 million tons, an increase of about 115% of the number of fingerlings in 2015. The minimum and the highest forecast period was about 19.87 and 36.03 million tons at the level Probability 95%.

Also the estimated value of the number of fishermen (X_3) in 2025 was estimated at 2040 fishermen by a decreasing 45.5% of the number of fishermen in 2015. The minimum and highest forecast period was about 173 and 7929 fishermen at the probabilistic level of 95%

While the estimated value of the average wholesale price (X_5) in 2025 was about 45.67 thousand pounds per ton, an increase of about 76.6% of the average wholesale price in 2015, and the minimum and higher forecast period about 21.33 and 76.74 thousand pounds per ton at the probability level 95%.

The expected value of salinity in the year 2025 was estimated at 35.09 g / l, a decrease of about 4.1% from the salinity rate in 2015. The forecast period between the minimum and the highest was 32.97 and about 37.27 g / l at the probabilistic level of 95%.

Using the double logarithmic model (4) in Table (5) and the expected values of the independent variables studied in Table (3) in the appendix, it was possible to predict the fish production of Qaroun Lake's fisheries during the period (2020-2025) as in Table (6) That the predicted quantity of fish production in 2020, 2025 is about 2992.7, 3676.4 tons increased by 21%, 48.6% of the average fish production during the period (1995-2015). It is also evident that the predicted quantity of fish production in 2025 is higher than the expected quantity of production in 2020 by 683.74 tons, with an increase of 22.8%.

By comparing the Maximum allowed Sustainable Production volume (MSY) estimated at 3653.59 tons with the expected production volume during the period (2020-2025), there is a deficit in the expected production during the years 2020, 2021, 2022, 2023 and 2024 m for the maximum allowed production volume of 22.1%, 20.5%, 17.2%, 12.5% and 6.5%, respectively. While a slight surplus in production expected in 2025 is 0.60% of the maximum allowed production volume, due to illegal fishing in previous years, which will lead to a reduction in the fish stocks of Qaroun Lake's fisheries.

Anticipating the fish production of Al-Rayyan lakes:

Using the exponential smoothing method, where the (Brown) model showed superiority according to the model's predictive accuracy tests. The statistical insignificance of the Ljung-Box serial correlation test for the independent variables under study indicates that there is no autocorrelation between the errors, in addition to the statistical significance of the adjustment coefficient (α) of the most impactful independent variables on the fish production in Al-Rayyan Lakes' fisheries according to model (8) in table (5), which will be used to predict the volume of fish production in the lake during the period (2020-2025). The value of the adjustment coefficient for the number of fishing boats (X_2, number of fishing boats), (X_4, number of fishing days) and (X_5, average the wholesale price) about 0.143, 0.220, 0.452 respectively.

The results of Table (4) in the appendix indicate that the expected value of the number of fishing boats (X_2) in the year 2025 is about 156 boats, with an increase of about 7.6% of the number of fishing boats in 2015, and the minimum and the highest forecast period is about 89 and 223 boats at the probabilistic level 95%.

The estimated value of the number of days of fishing (X_4) in 2025 was estimated at 200 days with a decrease of 9.1% of the number of fishing days in 2015. The minimum and the maximum duration of the forecast period was about 99 and 301 days at the probability level of 95%.

While the expected value of the average wholesale price (X_5) in 2025 was about 25.52 thousand pounds per ton, with an increase of about 49.7% of the average wholesale price in 2015, and the minimum and maximum forecast period about 12.91 and 38.13 thousand pounds per ton at the probability level 95%.

Adopting the linear model no.8 in Table (5) and the expected values of the independent variables studied in table (4) of the appendix, it was possible to predict the fish production of Al-Rayyan lakes' fisheries during the period (2020-2025) as in Table (7), where the expected quantity of fish production in 2020 is 2052, about 5352.52, 6597.31 tons, with an increase of 17.92% and 23.3% of fish production in 2015. It is also evident that the predicted quantity of fish production in 2025 is higher than the expected quantity of production in 2020 by 1244.8 tons, an increase of 23.26%.

By comparing the Maximum allowed Sustainable Production volume (MSY) estimated at 2369.23 tons with the expected production volume during the period (2020-2025), there is a surplus in the expected production during the years 2020, 2021, 2022, 2023, 2024 and 2025 m for the Maximum allowed Production volume of 55.7%, 57.7%, 59.5%, 61.2%, 62.7% and 64.1%, respectively, which means that illegal fishing is expected to continue if the re-planning of these fisheries is carried out, which may lead to a reduction in the fish stocks of these lakes.

Table 7: The fish production in Al-Rayyan Lakes' fisheries expected values during the period (2020-2025AD).

Years	Forecast	UCL (Upper Control Level)	LCL (Lower Control Level)
2020	5352.52	6048.58	4656.46
2021	5601.48	6549.88	4653.08
2022	5850.44	7066.29	4634.58
2023	6099.39	7596.86	4601.93
2024	6348.35	8140.82	4555.88
2025	6597.31	8697.57	4497.05

Source: calculated from table (4)'s data in the appendix and the estimating model in table (5).

Appendices

Table 1: Development of fish production and the most important economic and environmental variables in Qaroun Lake's fisheries during the period (1995-2015);

Years	Fish Production (ton)	Fingerlings (million units)	Fishing Boats (boat)	Fishermen Number (Fisherman)	Fishing Days (Day)	Salinity (gram/liter)	Sewage water (million cubic meter)	Average wholesale price (thousand pounds/ton)
1995	703	8.43	537	1970	264	35.52	702.35	7.82
1996	846	12.61	550	3560	283	35.87	684.14	7.08
1997	906	4.3	545	3563	210	34.12	623.74	9.76
1998	1025	9.75	550	2472	225	35.52	613.65	10.11
1999	1113	15.6	560	4000	274	36.97	543.56	9.03
2000	1819	14.32	567	4320	248	35.87	653.4	12.35
2001	1396	5.75	597	4455	229	34.81	510.72	11.12
2002	1925	11.7	494	4250	230	34.12	551.97	10.87
2003	2452	21.34	582	4277	230	34.12	626.48	11.75
2004	3037	22.48	582	4860	221	34.12	568.3	13.18
2005	2682	22	523	5085	226	35.52	697.79	14.36
2006	1648	9.61	528	4437	211	37.34	743.6	10.46
2007	3072	6.35	516	4626	215	34.47	685.71	14.4
2008	3184	13.01	539	4734	220	35.87	719.88	15.91
2009	3400	18.72	539	4680	200	35.52	678.85	18.27
2010	3903	27.42	542	4572	245	35.16	680.13	18.29
2011	4364	24.95	529	4500	224	35.52	473.4	20.21
2012	4410	8.9	529	4462	215	35.16	484.72	22.02
2013	4420	5.4	512	3964	210	35.16	432	22.95
2014	4518	6	425	4000	212	33.12	509.74	26.08
2015	1124	3.2	461	2968	203	36.6	398.36	25.86

Sources:

1 - Ministry of Agriculture and Land Reclamation, General Authority for Fisheries Development, Fish Production Statistics in G.M.A, miscellaneous numbers.

2. The Central Agency for Public Mobilization and Statistics, the Annual Bulletin of Fish Production Statistics, Miscellaneous Numbers, 1995-2016.

3 - Nile Valley area in Fayoum, Department of Cooperation and Leasing, unpublished data.

4- Ministry of Environment, Environmental Affairs Agency, Central Administration for Water Quality, Environmental Monitoring Program for Egyptian Lakes, Field Trips, Miscellaneous Numbers 1995-2016.

5 – The Egyptian Salts and Mineral Company in Fayoum, the Central Laboratory, unpublished data.

Table 2: The development of fish production and the most important economic and environmental variables in Al-Rayyan Lakes' fisheries during the period (1995-2015)

Year	Fish production (ton)	Fingerlings (million units)	Fishing boats (boat)	Fishermen numbers (fisherman)	Fishing days (day)	Sewage water quantity (million cubic meter)	Wholesale average price (thousand pounds/ton)
1995	611	4.6	173	1795	234	266.42	5.23
1996	702	5.34	205	1515	218	218.95	6.62
1997	876	2.28	206	1825	263	243.22	7.45
1998	1073	7.14	200	1409	241	264.12	7.68
1999	1654	6.23	164	1641	237	235.16	6.95
2000	1876	3.25	140	1540	265	237.6	8.45
2001	861	7.4	193	1793	255	256.3	8.28
2002	1191	5.6	148	1628	275	224.78	8.18
2003	1310	21	156	1716	235	234.09	7.81
2004	1271	10.11	174	1914	215	232.01	7.82
2005	1992	3.59	168	1848	200	234.87	8.06
2006	1691	13.32	150	1650	205	227.76	7.51
2007	2126	6.6	181	1991	225	228.05	10.32
2008	2055	9.7	194	2134	237	222.52	10.43
2009	2624	14.95	173	1903	200	224.83	10.26
2010	2494	13.25	175	1925	185	240.89	12.01
2011	3053	13.3	169	1859	197	232.2	13.8
2012	3451	8	187	2057	208	233.6	15.93
2013	3416	1.5	165	1800	195	210	14.81
2014	3782	0.5	170	2200	221	195	15.63
2015	4539	0.3	145	2200	220	180	17.05

Sources:

1- The Central Agency for Public Mobilization and Statistics, the Annual Bulletin of Fish Production Statistics, Miscellaneous Numbers, 1995-2016.

2 - Nile Valley area in Fayoum, Department of Cooperation and Leasing, unpublished data.

3- Ministry of Environment, Environmental Affairs Agency, Central Administration for Water Quality, Environmental Monitoring Program for Egyptian Lakes, Field Trips, Miscellaneous Numbers 1995-2016.

Table 3: The Exponential Smoothing Forecasting analysis's predicted results of the values of most important impacting independent factors on fish production in Qaroun Lake's fisheries during the period (2020- 2025).

Model Statistics

Model	Number of Predictors	Model Fit statistics Stationary R-squared	R-squared	RMSE	MAPE	MAE	Ljung-Box Q(18) Statistics	DF	Sig.	Number of Outliers
Fingerlings numbers-Model_1	0	0.310	-0.217-	8.066	79.123	6.368	20.020	17	0.273	0
Fishermen numbers Model_2	0	0.682	0.286	667.829	15.163	490.351	13.447	17	0.706	0
Salinity rate Model_3	0	0.794	-0.011-	1.034	2.226	0.784	20.153	17	0.266	0
Average wholesale price's Model_4	0	0.725	0.911	1.739	11.686	1.411	13.043	17	0.733	0

Exponential Smoothing Model Parameters

Model			Estimate	SE	T	Sig.
fingerlings- Model_1	Square Root	Alpha (Level and Trend)	0.230	0.093	2.469	0.023
Fishermen numbers Model_2	Square Root	Alpha (Level and Trend)	0.379	0.100	3.773	0.001
Salinity rate-Model_3	Square Root	Alpha (Level and Trend)	0.008	0.001	5.685	0.000
Average wholesale price-Model_4	Square Root	Alpha (Level and Trend)	0.361	0.084	4.279	0.000

Model		2019	2020	2021	2022	2023	2024	2025
fingerlings-Model_1	Forecast	5.27	5.17	5.21	5.40	5.73	6.23	6.88
	UCL	23.29	24.72	26.42	28.40	30.65	33.19	36.03
	LCL	1.68	3.15	5.17	7.80	11.09	15.10	19.87
Fishermen numbers Model_2	Forecast	2590.59	2445.08	2319.24	2214.44	2132.03	2073.37	2039.81
	UCL	5199.62	5518.61	5890.55	6315.97	6796.23	7333.23	7929.30
	LCL	751.09	453.21	221.65	67.67	1.75	33.78	173.25
Salinity rate Model_3	Forecast	35.14	35.13	35.13	35.12	35.11	35.10	35.09
	UCL	37.32	37.31	37.30	37.30	37.29	37.28	37.27
	LCL	33.01	33.01	33.00	32.99	32.98	32.97	32.97
Average wholesale price Model_4	Forecast	33.33	35.22	37.16	39.18	41.27	43.43	45.67
	UCL	44.74	49.12	53.87	58.99	64.51	70.42	76.74
	LCL	23.27	23.17	22.96	22.66	22.26	21.78	21.23

Table 4: The Exponential Smoothing Forecasting analysis's results of predicted values of the most impacting independent factors on fish production in Al-rayan lakes' fisheries during the period (2020-2025AD).

Model Statistics

Model	Number of Predictors	Model Fit statistics Stationary R-squared	RMSE	MAPE	MAE	Ljung-Box Q(18) Statistics	DF	Sig.	Number of Outliers
No. Fishing boats-Model_1	0	0.741	21.280	10.015	17.096	14.433	17	0.636	0
No. Fishing days-Model_2	0	0.564	22.302	8.041	17.943	12.521	17	0.768	0
Average whole sale price -Model_3	0	0.548	1.147	9.743	0.910	24.190	17	0.114	0

Exponential Smoothing Model Parameters

Model			Estimate	SE	T	Sig.
No. Fishing boats-Model_1	Square Root	Alpha (Level and Trend)	0.143	0.063	2.259	0.035
No. Fishing days-Model_2	Square Root	Alpha (Level and Trend)	0.220	0.069	3.170	0.005
Average whole sale price -Model_3	Square Root	Alpha (Level and Trend)	0.452	0.094	4.799	0.000

Model		2019	2020	2021	2022	2023	2024	2025
No. Fishing boats-Model_1	Forecast	161.06	160.24	159.42	158.60	157.78	156.96	156.14
	UCL	211.49	213.03	214.74	216.61	218.64	220.81	223.12
	LCL	110.62	107.45	104.10	100.59	96.93	93.12	89.17
No. Fishing days-Model_2	Forecast	205.23	204.34	203.44	202.55	201.65	200.76	199.86
	UCL	266.29	271.13	276.38	282.01	287.99	294.29	300.90
	LCL	144.17	137.54	130.50	123.08	115.31	107.22	98.82
Average whole sale price -Model_3	Forecast	20.36	21.22	22.08	22.94	23.80	24.66	25.52
	UCL	25.42	27.37	29.39	31.48	33.63	35.85	38.13
	LCL	15.29	15.06	14.76	14.39	13.96	13.46	12.91

RECOMMENDATIONS

Based on the findings of the research, the recommendations are as follows:

1. The concerned authorities (Ministries of Agriculture, Environment, Irrigation and Water Resources and Holding Company for Drinking Water and Sanitation) should remove the agricultural, industrial and health pollution from and on the lake regularly.

2. Intensifying the security campaigns of the water bodies police to prevent fishing during periods of prohibition and preventing overfishing using illegal nets and the concerned authorities to educate fishermen about the harm of using illegal fishing practices to preserve fish stocks.
3- Organizing the fishing effort by estimating the fish stock which enables us to determine the number of boats authorized to work by rationing licensed boats and stopping issuing new licenses due to the high fishing effort at present in Qaroun and Al-Rayyan lakes.
4- The inevitability of developing and operating marine hatchery for the production of marine fish fingerlings, especially fish species that can live in the water environment of Fayoum lakes.

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