



An Economic, Statistical and Social Study on the Impact of the Purification and Development Operations of Lake Edku, Egypt

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ABSTRACT

Egyptian fisheries including aquaculture represent an important sector in the national economy in addition to being a source of employment. All studies dealing with the stock assessment and fisheries management in Egypt confirmed the over-exploitation situation for almost all commercial stocks, which lead to a serious decrease in domestic fish production from natural resources. Although Egypt has vast fishing resources, marine and inland, it imports about 500 thousand tons annually to overcome the gap between production and consumption. Lake Edku is considered one of the important sources of fish production in Egypt. Nevertheless, numerous challenges arose causing the reduction in both the area and production of the lake, as well as hindering its development. This research shed light on Edku Lake during the period 2000-2019 in order to identify some of the physical characteristics of Lake Edku, and its relative importance, adding to the social and economic characteristics of fishermen and their families. Besides, the study suggested some proposals for the development and purification of the lake.

INTRODUCTION

Fishery resources in Egypt play an important role in the country economy since fish are considered one of the important food sources for human, which can contribute to bridging part of the nutritional gap of animal protein in Egypt. Besides, fish is a good source of vitamins, minerals and amino acids necessary for the human health. Therefore, there is a global and regional care about the fishery resources. In addition, there is a need to pay attention to fisheries as one of the productive activities that can contribute to the development or increase the national income on one hand, and as one of the most important sources of protein that must be available in human food on the other hand (Mehanna, 2021).

Those who are interested in the Egyptian fisheries activities have supported fish farming with all the available capabilities of the country, and the private sector has heavily supported in this field. All natural Egyptian fisheries are facing difficulties and problems, causing a serious decline in its fish production. Thus, this sector cannot be relied on to overcome the food gap, and a due attention should be paid for capture

fisheries. Moreover, efforts should be bound to assess applicable solutions to enhance the wild fish stocks and protect them from overfishing, spread of pollution by various sources, illegal fishing practices, climate change and habitat loss that impede production and decrease the quality of caught fish.

The Mediterranean basin in Egypt includes five northern lakes, arranged from the west to the east as follows: Mariut, Edku, Burullus, Manzala and Bardawil. These lakes are significantly important in terms of fish production that amounts for about 40% of the total fish production in Egypt (**Mehanna, 2008; El Kafrawy *et al.*, 2019**). The lakes are suffering from a range of challenges, including the severe decline of their area, habitat loss, vegetation and problems resulting from the expansion of agricultural, industrial activities and fishfarms.

Lake Edku is one of the most threatened aquatic wetlands in Egypt due to anthropogenic activities and pollution. This present study was undertaken to investigate the relative importance of lake Edku during the period from 2000 to 2019, main challenges, the socio-economic factors affecting fishermen communities in the lake, as well as evaluating the efforts exerted to develop and purify the lake.

MATERIALS AND METHODS

To achieve the objectives of the study, the descriptive and analytical economic methods were used based on time series of data during the period from 2000 to 2019. Additionally, percentages and arithmetic averages were used to evaluate the relative importance of different fish species in Edku Lake.

1. Study site

The northern lakes of Egypt are located along the Mediterranean coast, extending from Bardawil lagoon in the East to lake Mariut in the West for a distance of about 505km, and occupying separate areas along this coast of about 2314km² (**GAFRD Statistical book, 2019**; remote sensing maps). Lake Edku (Fig. 1) is an important fishing area in Egypt that is approximately at 30km to the east of Alexandria between Long. 30° 8' 30" and 30° 23' 0.0" E and Lat. 31° 10' 30" and 31° N. It receives its water from two sources, the drains and the Mediterranean Sea. Three main drains; namely, Edku El-Khairy, Bousaly and Bersik drains discharge their drainage water into the east of the lake. The drainage water contains unspecified quantities of urban, industrial and agricultural chemicals from Al-Beheira Governorate and beyond (**Abdel Halim *et al.*, 2013**). Sometimes, the sea water of Abu Qir Bay enters the lake through the lake-sea connection (Boughaz El-Maadeya) as subsurface water current under the action of wind, especially in winter (**Shakweer, 2006**). Its area decreased from 28.5 x 10³ to about 12x10³ feddan (**Okbah & El-Gohary, 2002**), reaching about 16.8km² (about 4000 feddan) in 2017 (**EEAA, 2017**), with a depth ranging from 50 to 150cm. Unfortunately, the lake lost about 77% of its surface area between 1957 and 2012 (**Mehanna, 2008; Moufaddal *et al.*, 2008; Shalaby, 2012**), and heavy vegetation covered the largest area of the lake (**Shawer & Ibrahim, 2010**).

2. Collection of data

The study relied on the published data of the General Authority for Fish Resources Development and what was issued by the National Institute of Oceanography and Fisheries, as well as research related to this subject during the study period. In addition, a field study during the year 2021 was conducted aligned with a personal interview via a questionnaire for the different lake centers in which fish are landed (El-Maadeya - Halt Al-Buhaira - No. 5 - Harb - Kom Al-Tarfaya - Edku Al-Balad.....etc.). A total of 350 questionnaires were distributed, 35 of which were excluded for lack of rationality. Thus, the sample size became 315 fishermen, representing about 14.1% of the total estimated employment in the lake in 2019 (2227 fishermen). These data represented the fishermen community throughout the lake and its various fishing gears used during the season 2021/2022. The questionnaire covered all data on the economic and social aspects of the fishermen and their families, such as age, fishing experience, fish income, educational status, health status, marital status, standard of living, fish training, indebtedness, their satisfaction about fishing work, etc...

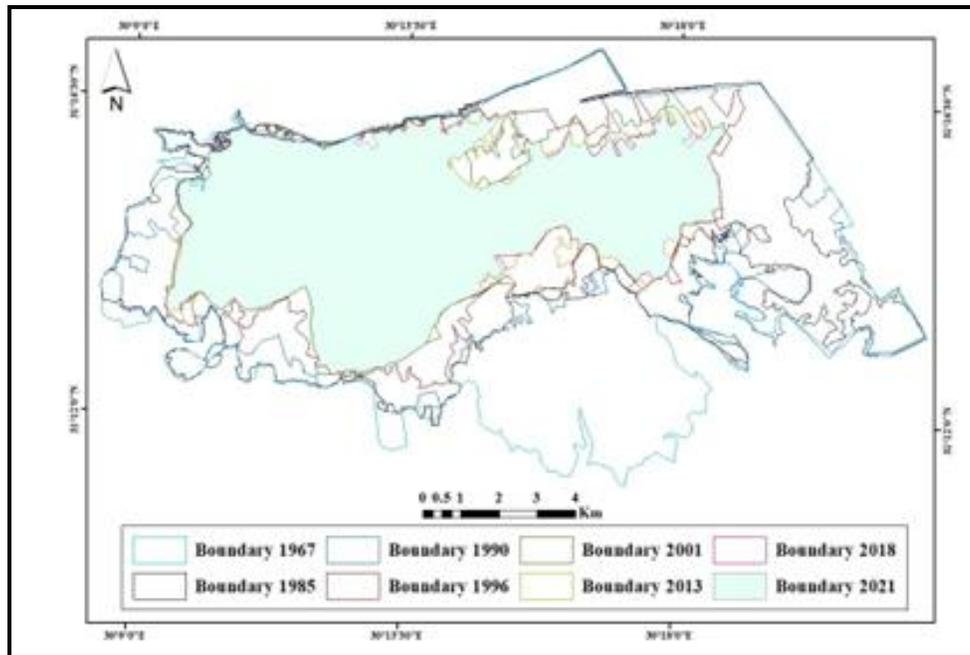


Fig. 1. Change in lake Edku surface area from 1967 to 2021 (after Said *et al.*, 2021)

3. Analytical framework

Different mathematical models was used to determine the general statistical trend using straight line equations in addition to the use of the second degree equation, as well as the use of both the cubic equation and the growth equation to test the best of them to clarify the direction of the dependent variable during the study period. Meanwhile, the study determined the predicting production in the years following the study; before and after the purification and development of the lake. Schaefer model was also used to

estimate the volume of production and the optimal effort in lake Edku in order to determine the optimal production quantities by assessing the appropriate number of fishing units that preserve the fish resource or fish stock from depletion.

RESULTS AND DISCUSSION

1. The hydrographic distribution of Edku Lake fisheries

Lake Edku is located in the northwestern part of the Al-Behaira Governorate. The lake is connected to the Mediterranean Sea at the village of El-Maadeya through Boughaz El-Maadeya. This Boughaz is the only connection point between the Mediterranean Sea and lake Edku, with a length ranging between 500- 600m and a width of about 170m. The fishing port of El-Maadiya is located on 200m apart from Al-Boughaz. All studies proved that the area of the lake decreased from 50,000 to about 15,000 feddan in the period from 1920 to 2019, reaching less than 12,000 fedan in 2021. In addition, the lake is used for drainage after the establishment of Edku El-Khairi drain and BersiK drain and linking them to the lake. This led to a great decrease in the lake salinity (increase in the freshness of the lake water), and consequently to the appearance of a dense vegetation cover of aquatic plants, spreading in about 53% of the water surface of the lake.

As a result of the absence of the development programs to enhance the lake before, the spread of aquatic plants in the lake led to the blockage of the water entry openings from the drains which feed the lake with water. Moreover, the siltation and the rise of the lake bottom led to the emergence of 70 islands, among which Al Taweelah, Al Naqaa, Diab, Al Dahra, Kosini islands are considered, with an area of 1400 feddan, representing 9.3% of the lake area. Based on the satellite images, **Said *et al.* (2021)** detected a great decline (about 58%) from 136.5 km² in 1967 to 56 km² in 2021. This increasing change in land cover resulted from the quantitative and qualitative changes in land use. Due to the high rates of poverty and unemployment, some residents infringed large areas of the lake's edges, converting them into houses and agricultural lands for their own account (**Moufaddal *et al.*, 2008**) in addition to the expansion in aquacultures in which large areas were transformed from free fishing areas to fishfarms, with no regulations.

Lake Edku is the third lake in the northern Delta Lakes following the Manzalah and Burullus Lakes regarding its productivity. Moreover, it is the main source of fish production in Al-Behaira Governorate. The lake is administratively located in three centers, Kafr El Dawar, Abu Homos and Edku Elbalad, and the main fish marketing centers are Edku Elbalad, Halt elbehaira, No. 5, Harb, Maadeya, Kom al-Tarfaya, Mansheyat Bassiouni, Elkanaies.

2. Current status of lake Edku fisheries

Upon studying the development of fish production from lake Edku during the period (2000-2019), it was noticed that, the production ranges between a minimum of about 5083 ton in 2016 and a maximum of about 10,910 ton in 2001, with an annual average of 7588.5 ton (Table 1). By analyzing the time series associated with fish production from lake Edku during the study period, it was found that, the best estimated results are the quadratic model in its following form $\hat{Y} = 12060.07 - 833.36 t + 29.82 t^2$ ($R^2 = 0.71$, $F = 20.74$ and $p < 0.01$), where \hat{Y} is fish production in tons, and t is the time. It

was obvious that the fish production from lake Edku fluctuated between increasing and decreasing amounts, but generally the fish production from the lake showed a decreasing trend by time (Fig. 2).

Table 1. Actual and estimated fish production (ton) from lake Edku during the period from 2000 to 2019

Year	Actual production (ton)	Estimated production (ton)	Annual rate of changes%
2000	8922	11256.5	-
2001	10910	10512.6	22.3
2002	10336	9828.3	-0.3
2003	10230	9203.7	-1.1
2004	9056	8738.7	-11.0
2005	9619	8133	7.2
2006	8986	7687.5	-7.0
2007	6645	7301.0	-26
2008	5891	7970	-11.3
2009	6206	6708	0.3
2010	6493	6500.9	4.6
2011	6387	7303.4	-1.6
2012	6576	6265.4	2.9
2013	6169	6237	-7.2
2014	5855	7278.0	-0.1
2015	5228	6359.4	-10.7
2016	5083	6510	-2.7
2017	7200	6720	41.6
2018	7972	6990	10.7
2019	8005	7319.6	0.4
Average	7088.0	7088.0	-
Change rate%	2.7		-

In respect to fish groups caught from lake Edku (Table 2), the main fish group was the tilapia species, locally known as Bolti. It constitutes the bulk of catch, forming 88.96% of the total fish production from the lake. Tilapia species showed a decreasing trend during the period 2000-2019 (Fig. 3), with a minimum catch in 2016 (4880 ton) and a maximum catch in 2001 (8541 ton). All other species together contributed by 11.1% of the total catch in lake Edku as follows: grass carp (4.5%), catfish (3.4%), grey mullet (2.9%), and eel (0.28%). According to CAPMAS (2019), fish production of lake Edku and its related economy changed along the past two decades. Lake area decline and pollution are key factors in production detraction and quality alteration rather than health and economic effect.

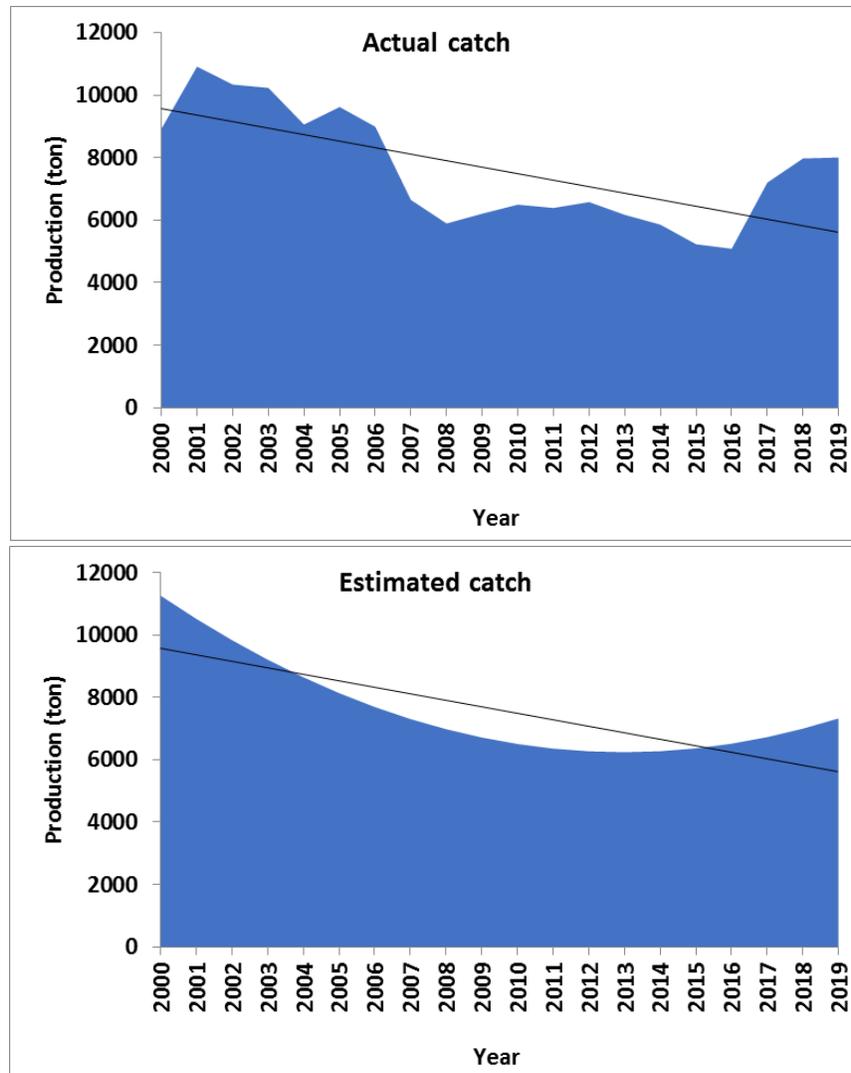


Fig. 2. Actual and estimated fish production trend from lake Edku during 2000 to 2019

3. Economic indicators in lake Edku

Three economic indicators affect the fish production in the lake, viz. the number of fishing boats, number of fishermen and the market prices (Table 3). The fishing boats used in the lake are third-class sailboats, such as Al-Sambak and Feluka with one to three fishermen per each boat. The number of fishing boats in lake Edku ranged between a minimum of 674 boat in 2019 and a maximum of about 1188 boats in 2000; however, these numbers may not reflect the real number of boats operating in the lake.

On studying the relationship between the number of boats and fish production in the lake, it was found that, the best estimated model is the linear model in the following form: $\hat{Y} = 3.669 + 8.601 X_1$ ($R^2 = 0.639$, $F = 21.06$, $p < 0.01$), where \hat{Y} is the yield and X_1 is the number of fishing boats. The results showed that, with the increase of fishing effort by one unit, the production will increase by 8.6 unit. In addition, it is obvious that, the

number of fishing boats is responsible for 64% of the changes in the fish production from lake Edku (Fig. 4).

Table 2. Fish production (ton) by species from lake Edku during the period from 2000 to 2019

Year	Bolti	Henshan (eel)	Grey mullet	catfish	Grass carp	others	Total
2000	6762	25	410	501	442	782	8922
2001	8541	13	703	938	566	149	10910
2002	7979	19	596	937	690	115	10336
2003	8425	48	582	373	775	27	10230
2004	7943	7	119	56	927	4	9056
2005	8480	2	152	103	872	10	9619
2006	7629	3	149	115	1074	16	8986
2007	6411	-	144	82	-	8	6645
2008	5744	-	97	45	-	5	5891
2009	6105	-	53	44	-	4	6206
2010	6383	-	59	51	-	-	6493
2011	6221	-	103	60	3	-	6387
2012	6339	6	146	73	9	3	6576
2013	5891	1	166	93	10	8	6169
2014	5600	5	140	87	11	12	5855
2015	4992	10	121	81	12	12	5228
2016	4880	9	109	60	12	13	5083
2017	6481	37	188	438	22	34	7200
2018	7097	73	204	514	31	53	7972
2019	7107	65	212	514	50	57	8005
Average	6750.5	21.5	222.7	258.3	344.1	72.9	7588.5
%	88.96	0.28	2.93	3.40	4.53	0.96	

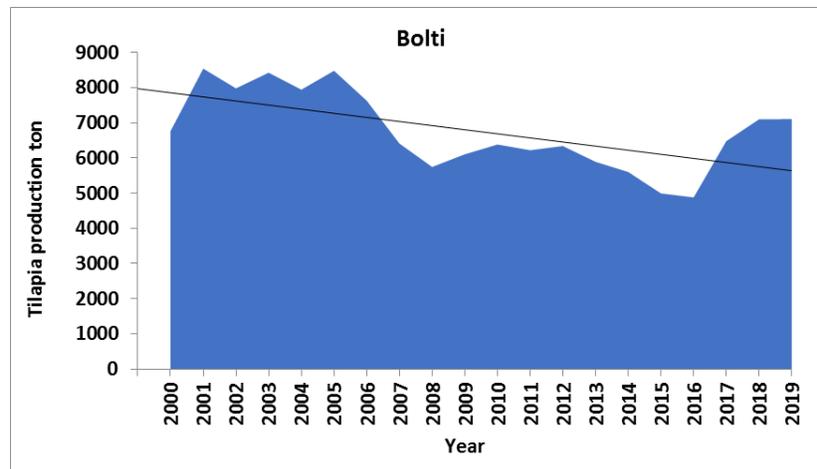


Fig. 3. Tilapia production trend from lake Edku during 2000 to 2019

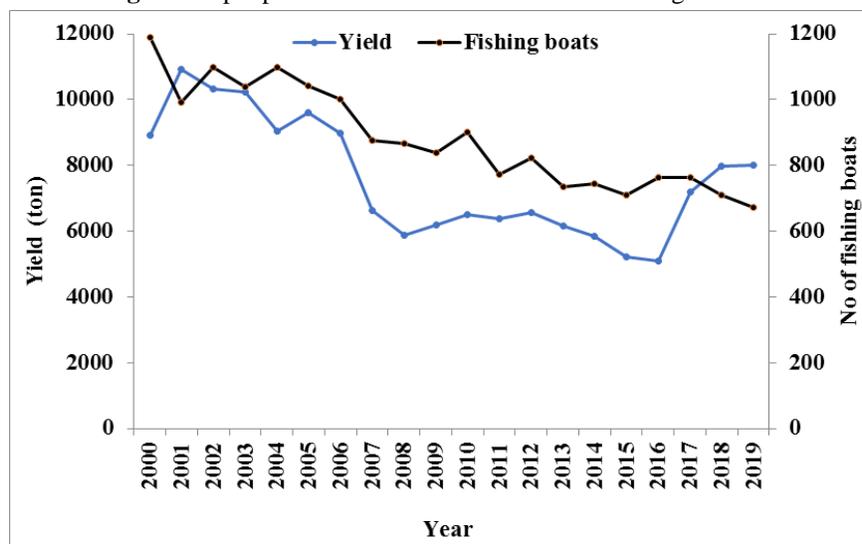


Fig. 4. Yield and number of fishing boats in lake Edku during 2000 to 2019

In respect to the fishermen in the lake, their number fluctuated between a minimum of 950 fishermen in 2014 and a maximum of 3564 fishermen in 2000, with an average of about 2562 fishermen during 2000-2019. It is worth mentioning that, this number of fishermen does not reflect the real number operating in the lake. By investigating the relationship between the fish production and the number of fishermen, the best estimated model was detected to be the linear model in the following form: $\hat{Y} = 1977.901 + 2.194 X_2$ ($R^2 = 0.684$, $F = 25.27$, $p < 0.01$), where X_2 is the number of fishermen. It was clear that, the number of fishermen is another factor affecting the fish production, and about 68% of the changes in fish production are caused by the changes in number of fishermen (Fig. 5).

On the other hand, the market prices showed an increasing trend from year to year, which may be due to the increase in the production costs and the decline of commercial fish species from the wild fisheries.

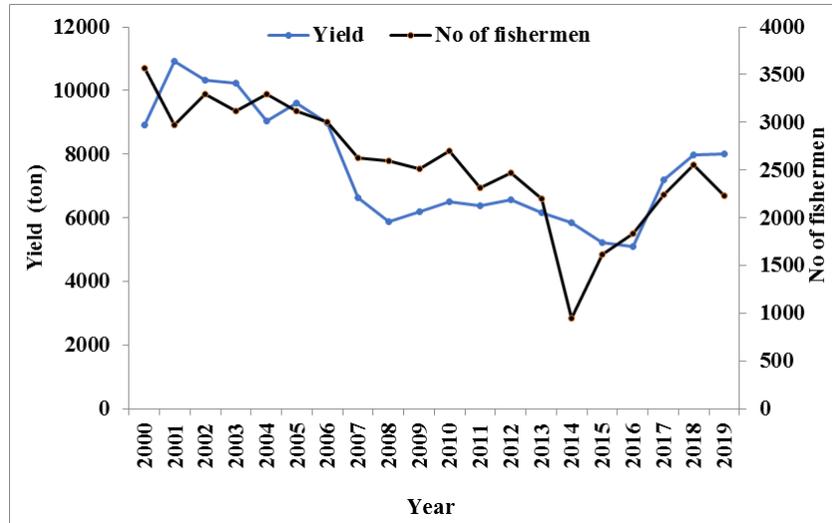


Fig. 5. Yield and number of fishermen in lake Edku during 2000 to 2019

Table 3. Economic factors affecting the fish production in lake Edku during 2000-2019

Year	Production Y (ton)	Number of boats X_1	Number of fishermen X_2	price per ton LE X_3
2000	8922	1188	3564	6100
2001	10910	992	2976	7200
2002	10336	1099	3297	6850
2003	10230	1039	3117	6900
2004	9056	1099	3297	7500
2005	9619	1041	3123	7400
2006	8986	1002	3006	7800
2007	6645	875	2625	9600
2008	5891	867	2601	7450
2009	6206	837	2511	8200
2010	6493	902	2706	8000
2011	6387	772	2316	8800
2012	6576	824	2472	9950
2013	6169	734	2202	9980
2014	5855	745	950	11600
2015	5228	710	1612	12400
2016	5083	763	1831	13400
2017	7200	762	2246	19100
2018	7972	711	2555	19,700
2019	8005	674	2227	25100
Average	7088.0	882	2062	10650

Upon applying Schaefer model (1954 & 1957) on the lake's relative abundance CPUE, it was found that, the catch of the lake could increase by the increase of fishing boats operating in the lake (Table 4 & Fig. 6). Nevertheless, we can't take any decision based on this result as the catch and effort data used are not reliable data and do not represent the real number of fishing boats. Hence, we should be careful about any suggestions to increase the fishing effort until improving the fishery statistics recording system or applying another analytical model for lake's management.

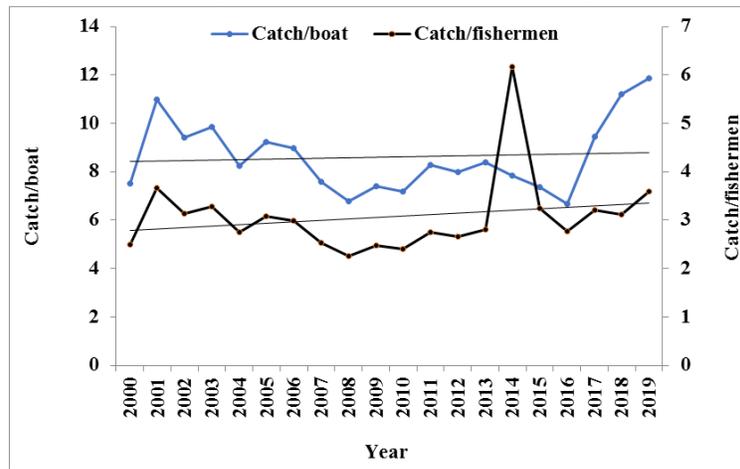


Fig. 6. Yield per unit fishing effort in lake Edku during 2000 to 2019

Table 3. Economic factors affecting the fish production in lake Edku during 2000-2019

Year	Production Y (ton)	Number of boats X_1	Number of fishermen X_2	price per ton LE X_3
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2017	7200	762	2246	19100
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Average	7088.0	882	2062	10650

Table 4. Catch per unit effort (ton /boat/year and ton/fisherman/year) in lake Edku during 2000-2019

Year	Production (ton)	Number of boats	Number of fishermen	Catch/boat	Catch/fishermen
٢٠٠٠	8922	1188	3564	7.51	2.50
٢٠٠١	10910	992	2976	11.00	3.67
٢٠٠٢	10336	1099	3297	9.40	3.13
٢٠٠٣	10230	1039	3117	9.85	3.28
٢٠٠٤	9056	1099	3297	8.24	2.75
٢٠٠٥	9619	1041	3123	9.24	3.08
٢٠٠٦	8986	1002	3006	8.97	2.99
٢٠٠٧	6645	875	2625	7.59	2.53
٢٠٠٨	5891	867	2601	6.79	2.26
٢٠٠٩	6206	837	2511	7.41	2.47
٢٠١٠	6493	902	2706	7.20	2.40
٢٠١١	6387	772	2316	8.27	2.76
٢٠١٢	6576	824	2472	7.98	2.66
٢٠١٣	6169	734	2202	8.40	2.80
٢٠١٤	5855	745	950	7.86	6.16
٢٠١٥	5228	710	1612	7.36	3.24
٢٠١٦	5083	763	1831	6.66	2.78
٢٠١٧	7200	762	2246	9.45	3.21
٢٠١٨	7972	711	2555	11.21	3.12
٢٠١٩	8005	674	2227	11.88	3.59
Average	٧٥٨٨.٥	٨٨٢	٢٥٦٢	8.61	3.07

4. Development and purification of lake Edku

Lake Edku received the greatest attention due to the serious decline in its area and its fish production. The pollution, the spread of islands and plants, overfishing and illegal fishing practices make it urgent to start a huge project to purify and develop the lake. About 97.12% of the purification processes from plants and weeds were conducted, and about of 73.66% of the first phase of dredging the lake was completed. Additionally, 4.56% of the work of the second phase of dredging the lake was previously done, and these works were arranged to end by 31/12/2022. All encroachments were completely removed by 1/12/2021. It was better for the cleansing and development operations to be carried out for the whole lake Edku area at the same time and not only in some parts of it to take advantage of the country's focused attention to this matter, and the advantages of the economics of the whole work over partial work. Moreover, by using the new technologies such as the remote sensing, it became easy to define the borders of the lake

with the free fishing areas, and the areas covered by plants, reeds, grasses and islands. Based on the remote sensing maps, we suggest that the cleansing and development operations should cover the entire area of the lake with the cost-benefit analysis and the extent of economic and social benefit to the fishermen community in the lake, and consequently to benefit at the national level.

By analyzing the remote sensing map of the lake in 2019, it was possible to calculate the following areas (Table 5): the area in 2019 is 63.2Km², equivalent to about 15 thousand feddan, and the free fishing areas in the lake occupied about 20.08Km², which is approximately equal to 4,780.9 feddan, or about 31.78% of the lake's area. The area needs to be developed by dredging to a level of (-1.5 m), so that it is difficult for plants and weeds to grow in it, and it continues as an area for free fishing, without future problems. About 33.3Km² were covered by the aquatic plants, this is about 7928.57 feddan, forming more than 52% of the entire lake area. To match remote sensing maps considering these areas at frequent intervals, necessary severe penalties should be taken and implemented, and a special immediate removal should be achieved to preserve the free fishing area in the lake. In addition, the purification process for the free fishing areas, and the area of islands and aquatic plants should be continued to increase the free fishing area. Furthermore, deepening water circulation, dredging the bottom where the pollutants and heavy metals are deposited and increasing the water column in the lake to prevent plant growth should be deployed.

Table 5. The lake Edku area based on remote sensing maps in 2019

Measuring unit Item	Km ²	Acres (feddan)	Relative importance to the lake area %
The entire area of the lake	63.2	15047.6	100
Free fishing areas	20.08	4780.90	31.78
Aquatic plants	33.30	7928.57	52.69
Fish farms	6.16	1466.67	9.70
Land	2.00	607.14	4.03
Agriculture	0.70	166.66	1.11
Agriculture school	0.24	57.14	0.38
The road	0.16	38.10	0.29

On the other hand, the purification and dredging work was carried out by the El-Beheira Governorate in lake Edku on an area of about 160 acres costing 16 million pounds (100,000 LE/feddan), as announced in 2017, and the lake was deepened from 70cm to a depth ranging from 150 to 200cm. These operations increased the free fishing area in the lake, raising the efficiency and the productivity of the acre, which would provide fish to the local market at reasonable prices, and help raise the living standard of

the fishermen communities. It is worth mentioning that, the purification and dredging work was done without removing the waste resulting from that, and the administration of lake Edku is still asking the governorate to remove it outside the lake. The resulting sedimentation basins limited the movement of water circulation in some areas and this problem is still present.

5. Development proposals of lake Edku

The first proposal was submitted by the General Authority for Fish Resources Development, Edku lake office, for a plan to develop 800 acres in lake Edku and transfer aquatic plants, reeds and grass to one of the islands in the lake (Ghattas Island). The disadvantage of this proposal was transferring the purification waste to an island inside the lake. In addition, the proposal targeted the deep areas only to be purified and developed, and this is another defect in the proposal because basically it is intended to dredge and clean the bottom of the lake and increase the level of water column to -1.5m.

The second proposal was submitted by the Arab Contractors (Department of Marine Constructions), which was presented under the name “project of clean and deepen lake Edku, 1200 acres facing the Boughaz El-Maadeya”. The project targeted a part of the lake and not the entire area, but the proposal mentioned the importance of this area to be cleared and deepened, and one of the most important feature of purifying this area is that it is directly located adjacent to Boughaz El-Maadeya, which adds great importance to this area due to its contribution to the development of the rest of the lake area. Besides, this area contains grass, reeds, and land high above the water; thus, it represents a barrier to sea water coming from the Boughaz to the lake. Due to water exchange, water quality in this area makes it an ideal environment for the growth and cultivation of varieties of fish. Rather, it will certainly help improving water quality in the rest of the lake, which consequently leads to enhance the quality of fish as well as increase productivity. The proposal indicated that the estimated quantities removed from the 1200 feddan area are about 5 million m³, at an estimated cost of about 120 million Egyptian pounds, with an emphasis on removing reeds from the place. The cost of clearing and deepening an acre = 100,000 pounds, which is equal to the cost of purifying and deepening the feddan carried out by the governorate. As the water quality of this area is the best in the lake, therefore, it is expected that one feddan will produce between 5 to 8 ton of fish per year.

On the other hand, we proposed to increase the free fishing area, the whole lake should be cleaned, and the Boughaz should be deepened and dredged to facilitate the sea water exchange, which leads to the removal of aquatic plants and increasing the lake fish production. The comparison among the three proposals is displayed in Table (6).

Table 6. Comparison among the three proposals for lake Edku development

Item	General Authority for Fish Resources Development, Edku Office	Arab Contractors Naval Construction) (Department	NIOF team proposal
edThe area to be clear and developed	800 acres next to Ghattas Island	1200 acres adjacent to Boughaz El-Maadeya	The whole area of the lake (12710 acres)
Relative importance of the cleared area	5.3%	8.0%	84.5%
The proposed cost	Didn't given	120 milloin LE	1249 million LE
Expected fish production	Didn't given	7800 ton (6.5 ton/acre/year)	٥٠,٨٣٨ ton (in the case 4 ton/acre) 67,074 ton (in the case 6.5 ton/acre)
Expected revenue	Didn't given	62 million LE	610 million LE (in case 4 ton/acre) 991 million LE (in case 6.5 ton/acre)
Number of boats to be increased	Didn't given	655 boat	1462 boat (in case 4 ton/acre) 2797 boat (in case 6.5 ton/acre)
Number of fishermen to be increased	Didn't given	1965 fishermen	4386 fishermen (in case 4 ton/acre) 8391 fishermen (in case 6.5 ton/acre)
Payback period	Didn't given	2 years	1.6 years

6. Cost/benefit analysis for different proposals

Due to the development project, it is expected that the price of the ton will be much higher than the current estimated price due to the increase in the entry of sea water through Boughaz El- Maadeya, along with a variety of marine fish species, such as mullet, eel, seabream and seabass that are characterized by their high prices.

By comparing the current situation of lake Edku according to the 2019 fishery statistics, with the expected one after purification and development using two scenarios: the production of an acre will be 4 ton, and in the other case will be 6.5 ton according to that estimated from the development proposals (Table 7). Remarkably, there is a great expansion in the production per boat and in the income of fishermen. With the current numbers of boats and fishermen as recorded in the annual fishery statistical book (GAFRD, 2019), the average production of the boat per year will increase from 11.9 to 75.4 ton/boat/year when the production of acre will reach 4 ton, while an increase to 122.6 ton/boat/year is expected when the acre production will be 6.5 ton. Consequently, the average production of the fisherman/year will increase from 4.0 ton in 2019 to 22.8 ton/fisherman/year if the production of an acre is expected to reach 4 ton/year and to 40.9 tons /fisherman/year in the case if the production of an acre is expected to reach 6.5 ton/year. This leads to an increase in the average income of the fisherman from (32) thousand pounds in 2019 to 274 thousand pounds in the case of an average production of 4 ton/acre/year, and to 490 thousand pounds in the case of an average production of 6.5

ton/acre/year. These expectations may be achieved if the number of boats and the number of fishermen remain constant as recorded in the 2019 statistics.

Table 7. Economical comparison using two scenarios along with the current one (2019)

Item	Current recorded statistics (2019)	Expected fish production after purification and development (deepening)	
		1 st case 4 ton/acre	2 nd case 6.5 ton/acre
Free fishing area	4781 acres	12,710 acres	12,710 acres
Total fish production	8005 ton	50,840 ton	82,615 ton
Average acre production / year	1.7 ton	4 ton	6.5 ton
Number of boats	٦٧٤	٦٧٤	٦٧٤
Number of fishermen	٢٢٢٧	٢٢٢٧	٢٢٢٧
Fish production income	64 million pounds	610 million pounds	991 million pounds
Average ton/boat/year	11.9	75.4	122.6
Average ton/fishermen/year	٤.٠	٢٢.٨	٤٠.٩
Average LE/fisherman/year	32,000 LE	274,000 LE	490,000 LE
Payback period	-	2 year	1.6 year

CONCLUSION

In conclusion, the present analysis of the cleansing and development of lake Edku revealed that it will be a very good investment due to the short recovery period of the invested capital. Additionally, the analysis showed the possibility of employing large numbers of new fishermen and save new jobs for unemployed youth with high income. In addition, after the purification and development operations, new activities may be established such as tourist villages, restaurants and cafeterias, fishing club, water sports center, a commercial center, cinema and theater, etc... All these activities would help in creating many new jobs, securing food and raising the standard of life of the Edku City and the adjacent areas. As the scientific advice is very important for such projects and can maximize the benefits from the development operations of the Egyptian lakes, the cooperation between the governmental bodies and the scientific research institutes is essential. Prevention of pollution and monitoring the industrial and sewage waste dumped into the lakes are highly needed to conserve the aquatic life and improve the water quality as well as the quality and quantity of caught fish. Consequently, the economic, social and health levels of fishermen communities would witness improvements.

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