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Estimating the value of investments and imports for achieving food security for fish

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Abstract
We research current scenarios to estimate the value of the investments and imports needed to achieve different levels of food security for fish in Egypt. We use the strategic stock estimation equations, the food security coefficient, the distribution of Bernoulli, and the standard errors at 95% confidence. The results are as follows. The strategic stock of fish reached 376,350 tons. With local consumption of 1.71 million tons in 2015, the fish food security coefficient was estimated at 0.22. The relative importance of the contribution of local production of fish security ranged from 14.05 to 20.95% at 95% confidence, while that of imports ranged from 1.15 to 8.05% at 95% confidence. Achieving full fish security requires an increase in production by 1.09 million tons to at most 1.62 million tons and an increase in fish imports from 88,760 tons to at most 621,350 tons, both at 95% confidence. The value of additional investments at a 10% discount rate to achieve full fish security ranged from at least 6.28 billion pounds to at most 9.35 billion pounds, while the value of the increase in fish imports ranged from at least 1.41 billion pounds to at least 9.85 billion pounds at 95% confidence.

Keywords Food security · Fish · Strategic stock · Investments · Imports

1 Introduction

Fish are important sources of animal protein, fats, vitamins, and minerals. Fish contains 20% of its weight in animal protein, similar to amino acids in chicken protein. Its advantage compared with beef-sourced protein is the superiority of its coefficient of utilization and easy of digestion. Fish also have fat ratios that vary with species. They are rich in vitamins, especially vitamin D. The percentage of mineral salts in fish ranges from 3 to 7% of dry weight (Ghanem and Alobaied 2002). Without the ability to increase fishery production capacity of traditional fisheries (seas and lakes), fish farming has become a matter

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of concern for the Saudi state. The production of fish farms increased from 323,700 tons (representing 44.7% of the total fish production) in 2000 to 1.36 million tons (representing 79.54% of the total fish production) in 2016. Because fish production failed to meet local consumption needs, the country was forced to expand its imports, increasing them from 213,630 tons valued at 479.41 million pounds in 2000 to 296,060 tons valued at 5752.97 million pounds in 2015 (Central Public Mobilization and Statistics 2018).

The Egyptian economy has been exposed to many political, security, and social crises since January 2011, leading to a GDP decline, an increase in the balance of payments deficit, higher prices and inflation rates, and an increase in poverty rates. These changes have affected the reality and future of food security in Egypt. We thus raise several questions, the most important of which are: What is the level of food security vis-à-vis fish (*fish security* hereon) in Egypt? What is the relative importance of the contribution of domestic production and Egyptian imports to the present fish security? What amount of increase in domestic production and imports would achieve the expected fish security in Egypt? What additional investments and imports are needed to achieve the expected fish security in Egypt?

We thus study the current scenario to estimate the value of the investments and imports necessary to achieve different levels of fish security in Egypt by studying the following Objectives:

- Assess the status of fish security in Egypt during 1990–2015.
- Assess the relative importance of the contribution of domestic production and imports to the relative fish security.
- Calculate the amount of increase in domestic production and fish imports required to achieve different levels of fish security.
- Estimate the value of additional investments and fish imports necessary to achieve expected fish security in Egypt.

2 Materials and methods

We use the following methods to achieve our research objectives:

(a) We use equations to estimate strategic stocks and security parameters of fish. These equations are as follows (Ghanem 1997):

  - The period of production adequacy of consumption = total domestic production ÷ domestic daily consumption
  - Period of coverage of imports for consumption = total imports ÷ daily domestic consumption
  - Amount of surplus and deficit in fish = [(total length of production and import coverage periods − 365) × domestic daily consumption (− quantity of exports).
  - Fish security coefficient = strategic stock (surplus and deficit) ÷ average annual domestic consumption. This value can also be estimated using the ratio of change in strategic stocks to annual domestic consumption. The value of the fish security coefficient ranges from zero to one. The closer the value of the fish security coefficient to zero, the greater the fish insecurity, and vice versa; the closer it is to one, the greater the fish security (Ghanem and Kamra 2010). The strategic stock of a commodity is the quantities held by the government and the private sector to meet

the expected demand (ex ante demand) in local or to export for this commodity over a future period. The strategic stock over a given period of time is the sum of the surplus directed to the development of strategic stocks in some years and the amount of deficit that is withdrawn from that stock during the other years in which there is a deficit in domestic consumption. There are many factors influencing the organization and management of the strategic stock, including the periods of production adequacy and coverage of imports for domestic consumption, the temporal and spatial consumption differences and the conditions of the global commodity market (Ghanem 1997). According to food security considerations, the size of the strategic stock should be sufficient for domestic consumption for at least 6 months.

(b) We use the Bernoulli distribution (or binomial distribution) and standard errors at 95% confidence to estimate the proportion or probability of domestic production or imports contributing to the relative fish security during 1990–2015. The estimate is accompanied by standard errors considered when estimating confidence intervals. That is,

$$\text{Standard error of probability at 95\% confidence} \pm 1.96 * \sqrt{\frac{P(1-P)}{N}}$$

$$\text{95\% confidence interval for probability } P \pm 1.96 * \sqrt{\frac{P(1-P)}{N}}$$

where P the probability of contributing to fish security, $(1-P)$ is the probability of non-contribution, N represents the length of the time series (1990–2015) (Greene 2003).

The equations used to calculate the increase in domestic production and fish imports to achieve different levels of fish security are (Kamara 2014):

- The amount of increase in domestic production to achieve fish security = the relative importance of the contribution of local production × the amount of strategic stock required to achieve fish security
- The increase in imports for fish security = the relative importance of import contribution × Strategic stock amount needed to achieve fish security

We estimate the additional investments in terms of the average annual share of fish in investment costs during the life span of capital assets by estimating the cost of the capital assets of the fish farms, in addition to the annual production quantity. We thus apply the following equations:

- *Capital recovery factor* This coefficient is used to determine the value of the annual premium paid for the purpose of redeeming a particular monetary value over a specified period of time and a specific discount rate. The capital recovery factor is calculated using the following equation (Psacharopoulos and Patrinos 2004): $\mathrm{CRF} = \frac{i(1+i)^n}{(1+i)^n-1}$, where CRF is the capital recovery factor, i represents the discount rate, and n represents. The number of years or the default life of capital assets.
- Annual cost of capital asset costs = capital asset creation costs × capital recovery factor.
- Annual average fish share of investment costs = annual cost of capital assets ÷ average annual fish production.
- The value of the additional investments required to achieve a certain level of fish security = the annual average of the investment costs per ton of fish × the amount of increase in domestic production required to achieve the same level of fish security.

Finally, we based our study on secondary data from the annual bulletin of fish production statistics in Egypt issued by the Central Agency for Public Mobilization and Statistics in 2018. We also used preliminary data from a questionnaire and personal interviews of the directors of the fish farms in Kafr El-Sheikh governorate. We chose Kafr El-Sheikh because it has the highest number of fish farms spread across the widest area. The total area of fish farms in this governorate spans 126,860 feddans, representing 40.88% of the total area of fish farms in 2015 (Central Agency for Public Mobilization and Statistics 2018). We selected a random sample of 150 farms, representing 4.52% of the total number of farms in Kafr El-Sheikh, as well as 17 governmental farms in Alexandria, Damietta, Dakahlia, Sharqia, Kafr El-Sheikh, Beheira, and Ismailia. The government farm managers were contacted by e-mail.

2.1 Previous studies

In the past, economics scholars have dealt with fish security in studies on production, consumption, exports, and imports of fish. The Arab Organization for Agricultural Development (2017) reported that fish production in the Arab nation amounted to 5.02 million tons, representing 2.9% of the world fish production in 2016. Egypt, Morocco, and Mauritania are the most important Arab producers of fish, accounting for 75% of the total production of fish in the Arab world in 2016. The annual average per capita consumption of Arab countries was 11.8 kg, while the world average was 20.5 kg in 2016. Mohammed (2017) showed that Egypt's natural fisheries production exceeded the average production target in 2000–2014: 406,000 tons compared with 383,000 tons. Fish consumption is expected to increase from 1.82 million tons in 2017 to 2.05 million tons in 2020.

We thus recommend formulating production and consumption policies for fish by considering the target levels of increasing production and average per capita consumption to achieve fish security.

Egypt was interested in fish farming. So, Faraj Allah et al. (2010) show that the production of fish farms can be controlled in terms of fish variety, nutrition, and sizes. Fish farms contributed to about 44% of the average fish production of Egyptian fisheries during 1995–2008. Although fish farms are the main source of fish production in Egypt, lack of fish fries is a problem. Al-Rouby et al. (2018) show that the percentage of farms with fish fry shortages ranges between at least 92.7 to 100% at 95% confidence. The authors recommended the development of fish farming in Fayoum governorate, which would be coordinated with the Ministry of Irrigation and Water Resources and the General Authority for Fisheries Development for providing water, technical support, guidance, and the provision of fish feed at reasonable prices. Besides, funding for farm owners at appropriate interest rates and appropriate grace periods consistent with net cash flows for fish farms was suggested.

Evidently, most previous studies largely focused on production, consumption, and constraints of fish farming in Egypt. They neglected a quantitative assessment of the level of actual and expected fish security and the means to achieve it through increased fisheries investments and imports. Moreover, determining the contribution of both domestic production and imports for achieving fish security in Egypt was also neglected.

3 Results and discussion

3.1 Current status of fish security in Egypt

To study the development of Egypt's production, consumption, and external trade of fish during 1990–2015, we examine the data from Tables 1 and 2. The data show that domestic fish production increased from 320,160 tons in 1990 to 1.52 million tons in 2015—an annual increase of 7%. The local consumption of fish increased from 451,800 tons to 1.71 million tons—that is, 6.2% annually during the same period. Moreover, fish exports

Table 1 Production, consumption, exports, imports, and self-sufficiency rate of fish during 1990–2015. *Source*: Central Agency for Public Mobilization and Statistics. Annual Bulletin of Fish Production Statistics in the Arab Republic of Egypt, Miscellaneous Numbers, 1990–2017

Year	Production in 1000 tons	Consumption in 1000 tons	Exports by 1000 tons	Imports in 1000 tons	Self-sufficiency %ratio
1990	320.16	451.8	3.4	138.05	70.9
1991	320.53	408.3	2.26	90.03	78.5
1992	318.25	448.5	1.67	132.37	71.0
1993	326.52	340.6	1.24	94.7	95.9
1994	339.79	503.6	1.66	144.73	67.5
1995	407.12	547.9	0.93	142.0	74.3
1996	431.64	575.5	0.50	144.0	75.0
1997	457.04	662.1	2.23	207.4	69.0
1998	545.59	719.8	3.1	176.3	75.8
1999	658.93	841.5	0.70	193.2	77.1
2000	724.41	937.1	1.00	213.6	77.3
2001	771.52	1031.7	1.20	261.0	74.8
2002	801.47	932.2	2.60	154.4	86.0
2003	875.99	1008.9	3.1	163.0	86.8
2004	865.03	1064.0	1.90	220.8	81.3
2005	889.3	1072.6	5.10	188.5	82.9
2006	970.92	1314.6	4.00	207.6	73.9
2007	1008.01	1222.5	4.40	258.9	82.5
2008	1067.63	1306.6	6.73	137.0	81.7
2009	1092.89	1232.7	7.59	136.0	88.7
2010	1304.79	1477.4	10.60	257.0	88.3
2011	1362.17	1526.0	9.49	182.22	89.3
2012	1371.98	1605.0	11.95	340.24	85.5
2013	1454.40	1635.0	19.08	280.34	89.0
2014	1500.00	1704.0	30.72	354.58	88.0
2015	1520.00	1707.0	19.70	296.06	89.0
Average	834.85	1010.65	6.03	196.69	80.77
Standard deviation	408.80	439.11	7.27	70.38	7.55
Variance coefficient%	48.97	43.45	120.56	35.78	9.35

Table 2 General trend equations for the production and consumption, Egyptian foreign trade for fish, and periods of production adequacy and coverage of imports for domestic consumption during 1990–2015. *Source*: Compiled and calculated from the data in Table 1

Statement	Growth rate %	F	R^2	Equation
Production	7.0	750.26	0.97	$\ln \hat{Y}_1 = 5.645 + 0.070T$ $(142.29)^{**}(27.39)^{**}$
Consumption	6.2	376.24	0.94	$\ln \hat{Y}_2 = 5.969 + 0.062T$ $(120.13)^{**}(19.40)^{**}$
Exports	12.17*	69.61	0.86	$\hat{Y}_3 = 5.817 - 1.318T + 0.076T^2$
Imports	3.5	28.76	0.55	$\ln \hat{Y}_4 = 4.754 + 0.035T$ $(47.79)^{**}(5.36)^{**}$
Self-sufficiency ratio	0.8	17.40	0.42	$\ln \hat{Y}_5 = 4.279 + 0.008T$ $(144.90)^{**}(4.17)^{**}$
Period of production adequacy	0.8	14.44	0.42	$\ln \hat{Y}_6 = 5.574 + 0.008T$ $(188.86)^{**}(4.18)^{**}$
Period of import coverage	−2.8	23.67	0.50	$\ln \hat{Y}_7 = 4.684 - 0.028T$ $(53.00)^{**}(-4.86)^{**}$

*Significance at the probability level of 5%

**Significance at the probability level of 1%

ranged from at least 0.50 thousand tons in 1996 to 30,720 tons in 2014. In general, fish exports increased at a rate of 12.17% annually during the study period.

Fish exports are unstable, with the coefficient of variation in the quantity of fish exports amounting to 120.56%. As domestic production was insufficient in meeting local consumption needs, the country was forced to expand imports. Thus, the quantity of fish imports increased from 138,050 tons in 1990 to 296,060 tons by 2015—that is, an annual growth of 3.5%. As the annual growth rate of fish production exceeded its estimated domestic consumption, fish self-sufficiency increased from 70.9% in 1990 to 89% in 2015, increasing the self-sufficiency rate of fish by 0.8% per year.

The strategic fish stocks were estimated by estimating fish surplus and deficit during 1990–2015. The data in Table 3 show that:

- The time interval of production sufficiency for domestic consumption increased from 258.7 days in 1990 to 325 days in 2015—that is, an annual increase of 0.8% during 1990–2015. The period of import coverage for domestic consumption decreased significantly from 111.5 days in 1990 to 63.3 in 2015—that is, an annual decline of 2.8%.
- Fish surplus from domestic consumption for 1990, 1992–1993, 1995, 1997, 2002–2005, 2007, 2010, and 2015 showed that total surplus was estimated at 659,180 tons, sufficient for 140.9 days (or ~4.7 months) of consumption. The surplus is directed toward the development of strategic fish stocks to be withdrawn during the other years, indicating a shortage of fish for local consumption. The total deficit was 282.830 tons for 60.4 days (or ~2.01 months).

The amount of surplus directed toward the development of strategic fish stocks exceeded the deficit amount or the withdrawal from the stock. Thus, the deficit-to-surplus ratio reached 42.91% at the end of 1990–2015. According to the concept of strategic stocks as the *sum of surplus and deficit* during the study period, the strategic stock of fish was

Table 3 Production and import coverage periods, and the fish surplus and deficit in the Arab Republic of Egypt during 1990–2015. *Source*: Compiled and calculated from the data in Table

Year	Daily consumption per 1000 tons	Production efficiency per day	Period of import coverage per day	Total of two periods per day	Amount of surplus in 1000 tons	The amount of deficit per 1000 tons
1990	1.24	258.7	111.5	370.2	3.01	–
1991	1.12	286.5	80.5	367.0	–	–
1992	1.23	259.0	107.7	366.7	0.45	–
1993	0.93	349.9	101.5	451.4	79.38	–
1994	1.38	246.3	104.9	351.2	–	20.74
1995	1.50	271.2	94.6	365.8	0.29	–
1996	1.58	273.8	91.3	365.1	–	0.36
1997	1.81	252.0	114.3	366.3	0.11	–
1998	1.97	276.7	89.4	366.1	–	1.01
1999	2.31	281.5	83.8	365.3	–	0.07
2000	2.57	282.2	83.2	365.4	–	0.09
2001	2.83	273.0	92.3	365.3	–	0.38
2002	2.55	313.8	60.5	374.3	21.07	–
2003	2.76	316.9	59.0	375.9	26.99	–
2004	2.92	296.7	75.7	372.5	19.93	–
2005	2.94	302.6	64.1	366.8	0.10	–
2006	3.60	269.6	57.6	327.2	–	140.08
2007	3.35	301.0	77.3	378.3	40.01	–
2008	3.58	298.2	38.3	336.5	–	108.70
2009	3.38	323.6	40.3	363.9	–	11.40
2010	4.05	322.4	63.5	385.8	73.79	–
2011	4.18	325.8	43.6	369.4	8.9	–
2012	4.40	312.0	77.4	389.4	95.27	–
2013	4.48	324.7	62.6	387.3	80.66	–
2014	4.67	321.3	76.0	397.3	119.86	–
2015	4.68	325.0	63.3	388.3	89.36	–
Total	–	–	–	–	659.18	282.83
Strategic stock in 1000 tons					376.35	
Fish security coefficient					0.22	

estimated at 376,350 tons. This is sufficient for 80.4 days (about ~2.7 months) of consumption. The fish security coefficient was estimated at 0.22 considering strategic stocks and local fish consumption of 1.71 million tons. Therefore, that increasing strategic stocks to meet local consumption for at least 6 months would improve fish security.

3.2 Estimating the relative importance of the contribution of domestic production and imports to achieve relative fish security

Data from Table 4 show that fish security depends on both domestic production and imports. Considering the strategic stock and fish security coefficient of 0.22 at the end of 1990–2015, the relative importance of the contribution of domestic production to achieving

Table 4 The relative importance of the contribution of domestic production and imports to fish security during 1990–2015. *Source*: Compiled and calculated from the data in Tables 1 and 3

Statement	Strategic stock in 1000 tons	Fish security coefficient	Local production	Imports
1990–2015	376.35	0.22	17.5%	4.6%
The possibility of contributing to the achievement of fish security			0.175	0.046
The likelihood of not contributing to fish security			0.046	0.175
The standard error of potentially contributing to fish security			0.018	0.018
Standard error at 95% confidence			0.034	0.034
Contribution to fish security at 95% confidence			0.175 ± 0.034	0.046 ± 0.034
Contribution to fish security at 95% confidence				
Maximum			20.95%	8.05%
Minimum			14.05%	1.15%

the current fish security ranged between at least 14.05% and at most 20.95% at 95% confidence. The relative importance of the contribution of imports to the present fish security ranged between at least 1.15% and at most 8.05% at 95% confidence.

We now consider achieving different levels of fish security. The data in Table 5 clearly show that, with a fish security coefficient of 0.50, the relative importance of local production contribution is between at least 31.8% and at most 47.4% at 95% confidence. Moreover, with complete fish security (reaching one), the relative importance of local production contribution is between at least 63.6% and at most 94.80% at 95% confidence.

Regarding the relative importance of imports in achieving different levels of fish security, the data in Table 6 show that, with a fish security coefficient of 0.50, the relative importance of the import contribution is between at least 2.6% and at most 18.2% at 95% confidence. With complete fish security, the relative importance is between at least 5.2% and at most 36.4% at 95% confidence.

3.3 Amount of increase in fish production and imports necessary to achieve different levels of fish security

Considering strategic stocks and domestic consumption in 2015, the fish security coefficient was 0.22 at the end of 1990–2015. To increase the level of fish security, strategic stocks need to be increased by increasing both domestic production and fish imports. Thus, considering the minimum and maximum contribution of domestic production and imports to achieve fish security at 95% confidence, we estimated the corresponding minimum and maximum amount of increase in domestic production and imports needed to achieve different levels of fish security. The data in Table 7 show that, to achieve fish security of 0.50, the increase in fish production must range from at least 271,410 tons to at most 404,560 tons at 95% confidence. The increase in fish imports must range between at least 22,190 tons to at most 155,340 tons at 95% confidence. To achieve complete fish security, the increase in fish production must range from at least 1.09 million tons to at most 1.62 million tons at 95% confidence. The increase in fish imports must range from at least 88,760 tons to at most 621,350 tons at 95% confidence.

3.4 Estimating the value of additional investments and imports necessary to achieve different levels of relative fish security

To estimate the value of additional investments needed to achieve different levels of fish security, the main source of fish production needs to be identified. The data in Table 8 show that fish farms are the main source of fish production in Egypt, where the production amounted to 1.36 million tons valued at 24.92 billion pounds in 2016. Fish farms ranked first in the quantity and value of fish production. The relative importance of the quantity and value of their production was 79.54% and 77.14%, respectively. Lakes ranked second, followed by marine water, freshwater, and rice fields. If we were to anticipate a water crisis from Al Nahda dam's establishment in the State of Ethiopia, achieving relative fish security would require an expansion in the number and production of marine fish farms. We would also require an estimate of the annual average share of fish in the value of initial investments for marine fish farm establishment.

The investment costs of fish farms include the value of the land on which the project is built, construction costs, construction of ponds and bridges, and purchase of machinery and equipment (agricultural tractor, irrigation machine, car, generator, agricultural trailer,

Table 5 The relative importance of the contribution of domestic production in the presence of imports for achieving different levels of fish security. *Source*: Compiled and calculated from the data in Tables 1 and 3

Statement	The relative importance of production contribution to different levels of fish security							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
The possibility of contributing to the achievement of fish security	0.238	0.317	0.396	0.475	0.554	0.634	0.713	0.792
The likelihood of not contributing to fish security	0.062	0.083	0.104	0.125	0.146	0.166	0.187	0.208
The standard error of potentially contributing to fish security	0.024	0.032	0.040	0.048	0.056	0.064	0.072	0.080
Standard error at 95% confidence	0.047	0.062	0.078	0.094	0.109	0.125	0.140	0.156
Contribution to fish security at 95%	0.238 ±0.047	0.317 ±0.062	0.396 ±0.078	0.475 ±0.094	0.554 ±0.109	0.634 ±0.125	0.713 ±0.140	0.792 ±0.156
Contribution to fish security at 95% confidence								
Maximum	28.47%	37.94%	47.40%	56.87%	66.33%	75.87%	85.34%	94.80%
Minimum	19.13%	25.46%	31.80%	38.13%	44.47%	50.93%	57.26%	63.60%

Table 6 The relative importance of the contribution of imports in the presence of domestic production for achieving different levels of fish security. *Source*: Compiled and calculated from the data in Tables 1 and 3

Statement	The relative importance of the contribution of imports to different levels of fish security							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
The possibility of contributing to the achievement of fish security	0.062	0.083	0.104	0.125	0.146	0.166	0.187	0.208
The likelihood of not contributing to fish security	0.238	0.317	0.396	0.475	0.554	0.634	0.713	0.792
The standard error of potentially contributing to fish security	0.024	0.032	0.040	0.048	0.056	0.064	0.072	0.080
Standard error at 95% confidence	0.047	0.062	0.078	0.094	0.109	0.125	0.140	0.156
Contribution to fish security at 95%	0.062 ±0.047	0.083 ±0.062	0.104 ±0.078	0.125 ±0.094	0.146 ±0.109	0.166 ±0.125	0.187 ±0.140	0.208 ±0.156
Contribution to fish security at 95% confidence								
Maximum	10.87%	14.54%	18.20%	21.87%	25.53%	29.07%	32.74%	36.40%
Minimum	1.53%	2.06%	2.60%	3.13%	3.67%	4.13%	4.66%	5.20%

Table 7 The increase in both domestic production and fish imports for achieving different levels of fish security. *Source*: Compiled and calculated from the data in Tables 5 and 6

Level of fish security	Strategic stock in 1000 tons	Increase in strategic stocks		Local consumption in 1000 tons in 2015	Amount of increase in fish production per 1000 tons		The increase in fish imports in 1000 tons	
		Quantity in 1000 tons	%		Minimum	Maximum	Minimum	Maximum
0.22	376.35	–	–	1707	–	–	–	–
0.3	512.1	135.75	36.1	1707	97.96	145.79	7.84	55.67
0.4	682.8	306.45	81.4	1707	173.84	259.05	14.07	99.28
0.5	853.5	477.15	126.8	1707	271.41	404.56	22.19	155.34
0.6	1024.2	647.85	172.1	1707	390.53	582.46	32.06	223.99
0.7	1194.9	818.55	217.5	1707	531.37	792.58	43.85	305.06
0.8	1365.6	989.25	262.9	1707	695.50	1036.08	56.40	396.98
0.9	1536.3	1159.95	308.2	1707	879.69	1311.08	71.59	502.98
1.0	1707.0	1330.65	353.6	1707	1085.65	1618.24	88.76	621.35

Table 8 The relative importance of the quantity and value of fish production of various Egyptian fisheries in 2016. *Source*: Central Agency for Public Mobilization and Statistics, Annual Bulletin of Fish Production Statistics in the Arab Republic of Egypt, January, 2018

Fisheries	Quantity in 1000 tons	Value in million pounds	Relative importance %	
			Quantity	Value
Marine water				
The Mediterranean Sea	53.96	1726.40	3.16	5.34
The Red Sea	49.69	1002.22	2.91	3.10
Total marine water	103.65	2728.62	6.07	8.45
Lakes				
Status	42.31	757.82	2.48	2.53
Al-Borlos	67.58	1409.47	3.96	4.36
Bardawil	4.09	143.48	0.24	0.44
Edco	5.08	77.75	0.30	0.24
Qaroon	0.88	29.56	0.05	0.09
Low Al Rayyan (1, 3)	5.97	118.47	0.35	0.37
Mariout	8.56	133.78	0.50	0.41
Naser Lake	18.35	256.68	1.08	0.79
Sour lakes, Al-Temsah, and Suez Canal	3.06	93.26	0.18	0.29
Toshka	0.16	2.40	0.01	0.01
Water bodies	2.45	52.20	0.14	0.16
Total lakes	158.48	3074.87	9.29	9.52
Fresh water	73.48	1350.62	4.31	4.18
Fish farms	1357.13	24,922.17	79.54	77.14
Rice fields	13.54	231.45	0.79	0.72
Total fisheries	1706.27	32,307.73	100.00	100.00

Table 9 Structure of the investment costs of national and government fish farms. *Source*: Compiled and calculated from the initial data of questionnaire forms collected in 2018

Statement	Investment costs 1000 lb	%	Life span
The value of the land on which the farm is located	4491.95	48.75	100
Cost of building construction	1241.51	13.47	50
The cost of constructing ponds and bridges	1798.08	19.52	30
The cost of purchasing machinery equipment	1396.11	15.15	10
Value nets and fishing tools	285.95	3.10	3
Total	9213.60	100.0	–
Average farm area in acres	50.84	–	–
Average fish production per ton	190.65	–	–
Average productivity per acre	3.75	–	–

Table 10 The annual average of the share of fish ton of investment costs during the real life of capital assets in fish farms. *Source*: Compiled and calculated from the data in Table 9

Statement	Capital recovery factor	The annual installment of costs is in 1000 lb	The share of tons of costs per 1000 lb
Fish share of investment costs at 5% discount rate			
Land	0.050	224.60	1.18
Buildings	0.055	68.28	0.36
Ponds and bridges	0.065	116.88	0.61
The machines and the equipment	0.130	181.49	0.95
Nets and fishing tools	0.367	104.94	0.55
Total fish share of the investment costs in 1000 lb			3.65
Fish share of investment costs at 10% discount rate			
Land	0.0996	447.40	2.35
Buildings	0.1004	124.65	0.65
Ponds and bridges	0.106	190.60	1.00
The machines and the equipment	0.162	226.17	1.19
Nets and fishing tools	0.395	112.95	0.59
Total fish share of the investment costs in 1000 lb			5.78
Fish share of investment costs at 15% discount rate			
Land	0.1482	665.71	3.49
Buildings	0.1483	184.12	0.97
Ponds and bridges	0.150	269.71	1.41
The machines and the equipment	0.196	273.64	1.44
Nets and fishing tools	0.423	120.96	0.63
Total fish share of the investment costs in 1000 lb			7.94

irrigation station, plow, etc.). The data in Table 9 show that the average investment costs of national and private fish farms amounted to 9.21 million pounds, that is, 181,230 lb/feddan. The cost of building ponds and bridges accounted for 19.52% of all costs, followed by purchasing machinery and equipment (15.15%). The cost of construction of buildings and nets and fishing tools was 13.47% and 3.10%, respectively.

And to distribute the initial investment costs over the life of the capital asset using the capital recovery factor at 5%, 10%, and 15% discount rates, respectively. The data in Table 11 show that to achieve fish security coefficient of 0.50, the value of additional investments for increasing domestic production at a 10% discount rate ranges from at least 1.57 billion pounds to at most 2.34 billion pounds at 95% confidence. To achieve full fish security, the value of additional investments for increasing domestic production at a 10% discount rate ranges from at least 6.28 billion pounds to at most 9.35 billion pounds at 95% confidence.

For fish imports, the average quantity of imports reached 290,890 tons with a value of 4.61 billion pounds. Thus, the average price of fish imports reached 15,860 lb/ton during 2011–2015 (Central Agency for Public Mobilization and Statistics 2018). Moreover, Table 11 also shows that the value of the increase in fish imports to reach a 0.50 fish security coefficient ranges from at least 351.93 million pounds and at most 2.46 billion pounds at 95% confidence. To achieve full fish security, the value of the increase in fish imports must range from at least 1.41 billion pounds to at most 9.85 billion pounds at 95% confidence.

4 Conclusion and recommendations

Our study of the current status of fish security in Egypt shows that despite the country's exposure to several economic, political, and security crises since 2011, it has managed to build a strategic stock of 376,350 tons of fish that is sufficient for not more than 2.7 months of domestic consumption. The fish security coefficient was 0.22 at the end of 1990–2015. Evidently, natural marine fisheries (Mediterranean and Red Sea) are known to be overfished. The increase in the number of fishing trips in the same area of fishing waters and the rate of biological growth have not kept pace with the rate of fishing (Ghanem 1992). The lakes were mostly exposed to environmental pollution, especially the lakes of northern Egypt (Mariout, Manzala, Burlus, and Idku).

Fish farms are the main source of fish production in Egypt. The relative importance of the quantity and value of fish farms production in total fish production was 79.54% and 77.14%,

Table 11 Value of additional investments needed to increase domestic production and value of increase in fish imports to achieve different levels of fish security. *Source*: Compiled and calculated from the data presented in Tables 7 and 10

Level of fish security	Value of additional investments to increase fish production by one million pounds at a discount rate of 10%		The value of the increase in fish imports in one million pounds	
	Minimum	Maximum	Minimum	Maximum
0.3	566.21	842.67	124.34	882.93
0.4	1004.80	1497.31	223.15	1574.58
0.5	1568.75	2338.36	351.93	2463.69
0.6	2257.26	3366.62	508.47	3552.48
0.7	3071.32	4581.11	695.46	4838.25
0.8	4019.99	5988.54	894.50	6296.10
0.9	5084.61	7578.04	1135.42	7977.26
1.0	6275.06	9353.43	1407.73	9854.61

respectively, in 2016. Despite the economic importance of fish farming, production has not reached self-sufficiency due to weak investment in this sector. Nevertheless, the production of fish farms can be controlled. Achieving relative fish security depends mainly on the expansion of the number and production of fish farms, especially the marine farms, such as the Ghalion farm in Kafr El-Sheikh governorate under the Egyptian Armed Forces. In Ethiopia, establishment of marine fish farms has been prioritized considering the expected water crisis from Al Nahda dam. Therefore, we recommend raising fish security by increasing the strategic stock so as to meet domestic consumption for at least six months. This requires: (1) increasing additional investments at a 10% discount rate to increase domestic production from at least 1.57 billion pounds to at most 2.34 billion pounds (95%); and (2) increasing fishery imports from at least 351.93 million pounds to at most 2.46 billion pounds at 95% confidence.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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