Websites:
http://www.sciencepub.net/nature
http://www.sciencepub.net

Emails:
naturesciencej@gmail.com
editor@sciencepub.net

Nature and Science

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

# Estimation of the production costs function and the optimal size of fish farms In Kafr El-Sheikh Governorate

Dr. Nivine Todary Guirguis Elbebawy[1], Dr. Howida E. Hassan[1] and Dr. Hussein El Sayed Hussein Sarhan[2]
[1] Senior Researcher, Agricultural Economics Research Institute, Agricultural Research Center, Egypt
[2] Associate Professor of Agricultural Economics, College of Agriculture, Ain Shams University, Cairo, Egypt

neveen.todary@gmail.com

**Abstract:** The aim of this research is to study the status of fish farming production in Kafr El Sheikh over time, study input costs and determine the optimum production level and farm size and compare with the current production level and production unit size. The study used secondary data analysis and adopted a field survey approach covering sixty fish farms in the four main aquaculture governorates conducted in 2020.

The study revealed that the fish feed cost, hired labor, and irrigation represent a large percentage of 75.4%, 10.3%, and 6% respectively, of the total variable costs, other important variables costs such as fish seed represent 3.2%, followed by pond maintenance at 3% and the incidental costs at 2%, of the total variable costs, the result indicated that fish farmers do not achieve the optimal production level, which amounts to 4.445 tons/feddan/year, the study recommends that we should work to enable farmers to achieve optimal yield that, achieves efficiency through the increasing average size of cultivated areas, the optimal culture area identified in the current study is 1.16 feddan.
[Nivine Todary Guirguis Elbebawy, Howida E. Hassan and Hussein El Sayed Hussein Sarhan **Estimation of the production costs function and the optimal size of fish farms In Kafr El-Sheikh Governorate** *Nat Sci* 2022, 20(11):14-21]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature

**Keywords**: Fish farms, Fish consumption per capita, Self-sufficiency, Costs function, Optimal size, Economies of scale-area

## 1. Introduction:

Egyptian government focused on developing fish farming as a source of income to achieve economic returns also; creating job opportunities for workers in the sector fish. Moreover, it is an important source of as well; fish meat is characterized by containing calcium, magnesium, iodine, and vitamins. Finally, fish is the main source of fatty acids that are necessary for the health of the skin, heart, and bones (El-Naggar et al., 2008; Pradeepkiran, 2019; Samarajeewa, 2022).

Fish production is one of the important sectors in the Egyptian national economy, as the value of fish production in Egypt amounted to about 62.9 billion pounds, with the value of requirements for this production amounting to about 27.3 billion pounds, representing about 43.4% of the value of fish production 2020 ((MALR), 2019). The policies adopted by the state have helped to encourage the development of the sector and a noticeable increase in fish production during the last two decades. Fish production has increased from 889 thousand tons in 2005 to 2.011 million tons in 2020. According to fisheries statistics, the main reason for the raise in fish production due to increase in the production of fish farms, while the fisheries' production increased from 349, 5 thousand tons to 419 thousand tons during the same period. The increase in fish farming production contributed to the increase in the average share of locally produced fish per capita from 12.6 kg/person/year in 2005 to 19.7 kg/person/year in 2020 ((MALR), 2019). Kafr El-Sheikh governorate is considered one of the governorates where fish farms are widespread due to its geographical location near the Mediterranean Sea, the presence of Lake Burullus, and the availability of water needed for farming from Lake Burullus and drains, as well as seawater. The spread of fish farms there is due to the owners of fishing crafts having experience in fishing that helped them work in the activity (El-Gayar & Management, 2003). According to General Authority for Fish Resources Development, the development of fish farming production in the governorate from 223 thousand tons in 2005 to 693 thousand tons in 2020, about 43.5% of the total fish farming production at the level of the Republic ((GAFRD), various issues).

The owners of fish farms work to provide all production inputs during the farming season, and they raise three types of fish (tilapia, mullet, and catfish), which are preferred by Egyptian consumers (El-Naggar et al., 2008; Kaleem et al., 2021).

**Problem:**

The research problem is summarized in the high costs of production inputs such as; feed, labor wages, and fuel. Also, the producers' failure to reach the optimum production level and the optimum farm area at which led to reduced production costs per unit of the product to the least possible extent to maximize the profitability of the producers and the sustainability of the activity.

In addition to the lack of studies on production costs, which have indicative and economic applications for agricultural policy, which can lead to an increase in fish production if fish farmers are directed to produce at optimal rates and use optimal areas for production.

**Objective:**

The main objective of the research is to estimate the production costs function, determine the optimal level of production, and determine the optimal area for the production unit. This is achieved through the following sub-objectives:

1. Studying developments in local fish production in Egypt, and fish production from fish farms in Egypt and Kafr El-Sheikh Governorate.
2. A study of the development of domestic consumption, average Fish consumption per capita, and the relative importance of fish self-sufficiency in Egypt during the period (2005-2020).
3. The relative importance and estimation of the variable and fixed costs of fish farms in the study sample.
4. Estimating the cost function and determining the optimal size of production and area for the fish farm and comparing it with the size and the area actually exploited in the study sample in Kafr El-Sheikh governorate.

## 2. Method and data sources:

In achieving its goals, the research relied on the use of the descriptive analysis method, which is concerned with explaining and presenting various theoretical aspects, describing data and linking them logically, and extracting important indicators through the use of simple statistical methods such as percentages and arithmetic averages, in addition to using the quantitative analysis method using some statistical methods. The occasion that serves the objectives of the study (Cobo et al., 2019; Elhendy et al., 2001; Iversen et al., 2020; Yuan et al., 2020).

The research also relied on secondary data from the publications of the General Authority for Fish Resources Development (GAFRD), in addition to many research and scientific studies related to the subject of the research.

The research depends on. Descriptive analysis of the data obtained through a description of costs and their relative importance. In addition, it relied on the primary data collected through questionnaires specially prepared to obtain fish farm data in the sample selected for the study during fish farming for the year 2020. To select a representative sample for the research were selected 60 fish farms were through simple random in Kafr El-Sheikh Governorate. The study sample (Gerald & Physics, 2018; Lin, 2018) reflected that fish farmers farm three main types of fish, at the forefront of which is (tilapia of the Nile), which constitutes the bulk of the production of fish farm owners, followed by (the family of mullet and catfish), and the sample showed that the owners of fish farms buy the fish production requirements during The season of fish fry, fodder, fuel, labor, and other requirements during the fish farming season; which extends from 6 to 8 months, depending on the size of the fish fry and the target marketing volume of fish farming. The data were collected and analyzed using the SPSS statistical analysis program.

## 3. Results and discussion

First: The development of fish production in Egypt and Kafr El-Sheikh Governorate:

1- The development of local fish production in Egypt:

Table No. (1) shows that the average domestic fish production, during the period (2005-2020), amounted to about 1,440 thousand tons, and it was found that the average domestic fish production in Egypt increased from what it was in 2005, at a rate of about 161.9%.

By estimating the time trend equation (Roth, 2022), the average local fish production, shown in equation No. (1) Table (2), that production is increasing by a statistically significant, to about 78.6 thousand tons annually at a significant level of 0.01, with a change rate of about 5.46%, from the average Total production. The value of the coefficient of determination ($R^2$) indicates that about 97% of the changes occurring in production are due to variables reflected by time, which in its content expresses the production, price and marketing policies during the study period, and the value of (F) shows the significance of the function at the level of 0.01.

### The development of fish farming production in Egypt:

Table No. (1) indicates that the average quantity of fish farming during the study period amounted to about 1070.3 thousand tons, and it was found that the average production of fish farming in Egypt increased from what it was in 2005 with a rate of about 198.2%.

The equation of the time trend of the average fish production from fish farming in Egypt in equation no. (2), in Table No. (2), indicates an increase in the average fish production from fish farming by a statistically significant annual rate of about 77.7 thousand tons at level of 0.01, with an rate of change It reached about 7.26% of the average production of fish farms in Egypt, and the value of the coefficient of determination ($R^2$)

shows that about 98% of the changes occurring in fish farming production are due to variables reflected by time, and the value of (F) shows a significant function at the level of significance 0.01.

**Table (1): Evolution of fish production and consumption and production of Kafr El-Sheikh Governorate and per capita share during the period (2005-2020) Production (thousand tons)**

| **Years** | local fish production | Production of fish farms in Egypt | Production of fish farms in Kafr El-Sheikh | Total domestic consumption of fish | per capita share of fish | % of self-sufficiency | % fish farms production | % The production of fish farms in Kafr El-Sheikh |
|---|---|---|---|---|---|---|---|---|
| 2005 | 889 | 540 | 223 | 1104 | 16 | 80.56 | 60.69 | 41.26 |
| 2006 | 971 | 595 | 295 | 1174 | 17 | 82.67 | 61.28 | 49.64 |
| 2007 | 1008 | 636 | 328 | 1263 | 17 | 79.84 | 63.05 | 51.58 |
| 2008 | 1068 | 694 | 373 | 1198 | 16 | 89.14 | 64.99 | 53.73 |
| 2009 | 1093 | 705 | 326 | 1221 | 16 | 89.52 | 64.55 | 46.21 |
| 2010 | 1307 | 922 | 420 | 1553 | 20 | 84.15 | 70.52 | 45.57 |
| 2011 | 1362 | 987 | 497 | 1535 | 19 | 88.75 | 72.44 | 50.33 |
| 2012 | 1372 | 1018 | 524 | 1691 | 21 | 81.12 | 74.18 | 51.52 |
| 2013 | 1454 | 1098 | 599 | 1670 | 20 | 87.10 | 75.46 | 54.58 |
| 2014 | 1482 | 1137 | 540 | 1808 | 21 | 81.94 | 76.73 | 47.45 |
| 2015 | 1519 | 1175 | 600 | 1795 | 20 | 84.61 | 77.35 | 51.05 |
| 2016 | 1706 | 1371 | 672 | 1970 | 22 | 86.63 | 80.33 | 48.99 |
| 2017 | 1823 | 1452 | 723 | 2154 | 23 | 84.61 | 79.65 | 49.82 |
| 2018 | 1935 | 1561 | 700 | 2233 | 23 | 86.65 | 80.29 | 44.84 |
| 2019 | 2039 | 1642 | 768 | 2510 | 25 | 81.23 | 80.53 | 46.77 |
| 2020 | 2011 | 1592 | 693 | 2282 | 22 | 88.08 | 79.2 | 43.53 |
| Averag | 1439.9 | 1070.3 | 517.6 | 1697.6 | 19.9 | 84.8 | 72.6 | 48.6 |
| % | 161.97 | 198.21 | 232.09 | 153.76 | 124.2 | 105.25 | 119.59 | 117.68 |

Source: Ministry of Agriculture and Land Reclamation, General Authority for Fisheries Development, Fisheries Statistics Yearbook. Miscellaneous numbers.

**Table No. (2): Equations of the time trend of fish production and consumption and the average per capita share of fish in Egypt during the period (2005-2020)**

| **Serial** | **Variables** | **The equation** | **Average** | **change amount** | **% rate of change** | $R^2$ | **F** |
|---|---|---|---|---|---|---|---|
| 1 | **The amount of local fish production in Egypt** | $Y_{i1}$= 771.32 + 78.653$X_i$ (24.6)** | 1439.9 | 78.6 | 5.46 | 0.97 | (608.2)** |
| 2 | **Fish production from fish farming in Egypt** | $Y_{i2}$= 409.75 + 77.713 $X_i$ (26.4)** | 1070.3 | 77.7 | 7.26 | 0.98 | (698.2)** |
| 3 | **Fish production from fish farming in Kafr El-Sheikh** | $Yi_3$= 217.97 + 35.245 $X_i$ (15.6)** | 517.6 | 35.2 | 6.81 | 0.94 | (244.2)** |
| 4 | **Domestic consumption of fish** | $Y_{i4}$= 928.02 + 90.53 $X_i$ (16.3)** | 1693.6 | 90.5 | 5.33 | 0.95 | (267.4)** |
| 5 | **Average per capita share of fish** | $Y_{i5}$= 15.25 + 0.544 $X_i$ (8.6)** | 19.9 | 0.544 | 2.73 | 0.84 | (73.8)** |

Where: (**) Significant at (0.01)
$Y_{i1}$= Domestic production of fish (in thousand tons). $Y_{i2}$= Fish farming production (in thousand tons) $Y_{i3}$= Production of fish farms in Kafr El-Sheikh (in thousand ton $Y_{i4}$= Domestic consumption of fish (in thousand tons). $Y_{i5}$= Annual average per capita in kilograms. Xi= Time Factor , I= Years (1,2,3,………16)

**Source: It was collected and calculated from the data in Table No. (1).**

**1- The development of fish farming production in Kafr El-Sheikh Governorate:**

Table No. (1) Shows that the average production of fish from fish farming in Kafr El-Sheikh governorate during the study period amounted to about 517.6 thousand tons, and it was found that the average production from fish farming in Kafr El-Sheikh governorate increased by about 232.1% than it was in 2005.

By estimating the equation of the time trend, equation No. (3) In Table No. (2) Shows that the production of fish produced from fish farming in Kafr El-Sheikh governorate is increasing statistically significantly by about 35.2 thousand tons annually at a significant level of 0.01, with an annual change rate of about 6.81 % of the average production of fish farming in the governorate. The value of the coefficient of determination (R2) indicates that about 94% of the changes occurring in fish production from fish farming in the governorate of Kafr El-Sheikh, are due to variables reflected by time, and the value of (F) shows a significant function at the level of significance 0.01. It is noted, that the annual rate of change in fish production from fish farming in Kafr El-Sheikh governorate is lower than the change in fish production from fish farming at the level of the Republic.

**2- The development of local consumption of fish in Egypt:**

Table No. (1) Shows that the average local consumption of fish during the period (2005-2020) amounted to about 1693.6 thousand tons and that the average local consumption of fish in Egypt increased by about 153.7% compared to its level in 2005.

By estimating the equation of the time trend of the development of domestic consumption, equation No. (4) In Table No. (2) shows that the average domestic consumption increased by a statistically significant increase by an annual rate of about 90.5 thousand tons, with an annual change rate of about 5.33% of the average domestic consumption of fish. Moreover, it was found that the increase is large compared to the increase in total production during the study period. The value of the coefficient of determination ($R^2$) indicates that about 95% of the changes in the average local consumption of fish in Egypt are due to variables reflected by time, as the value of (F) The significance of the function at the level of 0.01.

**Development of Fish consumption per capita in Egypt:**

Table No. (1) Indicates that the average Fish consumption per capita during the study period amounted to about 19.9 kilograms, and the average per capita consumption of fish increased from what it was in 2005 at a rate of about 124.2%.

By estimating the time trend equation for the average per capita share of fish, equation No. (5), in Table (2), shows that the average Fish consumption per capita was increasing by a statistically significant about 0.544 g annually at a significant level of 0.01, with an annual change rate of about 2.73%. The value of the coefficient of determination ($R^2$) shows that about 84% of the changes in the average per capita share of fish are due to variables reflected by time. The value of (F) significance at the level of 0.01 and the average Fish consumption per capita increased at a rate of 2.73% despite the annual increase in Population averaging 2.3% during the study period (2).

**The relative importance of fish self-sufficiency in Egypt:**

The local production of fish is the main component of supply and available for consumption, and by studying the self-sufficiency in the Republic and shown in Table No. (1), it became clear that self-sufficiency ranged from a minimum of about 79.84% in 2007 to a maximum of about 89.52% in 2009, and then the self-sufficiency rate decreased to about 85.32% as an average for the years (2018-2020). It also shows the relative importance of fish production from fish farming in Egypt to total production, ranging between a minimum of about 60.69 percent in 2005 and a maximum of about 80.53% in 2019, which shows that fish farming in Egypt is increasing during the study period. While the relative importance of fish farming in Kafr El-Sheikh governorate to the total agricultural production of the Republic ranged between a minimum of about 41.26% in 2005 and a maximum of about 54.58% in 2013, then the percentages ranged between increase and decrease until it reached about 48.6% as an average for the years (2015 -2020). Meaning that Kafr El-Sheikh contributes approximately 50% of the production of fish farms in Egypt.

**Second: The relative importance of production costs in a sample of fish farms in Kafr El-Sheikh Governorate:**

Table No. (3) Shows the relative importance of the average variable and fixed costs to the total costs per feddan in Kafr El-Sheikh Governorate. Where it was found that the average total variable costs per feddan were about 47.87 thousand pounds, representing about 75.5% of the total costs per feddan, which amounted to about 63.4 thousand pounds. One of the most important items of variable costs was the costs of industrial feed, which amounted to about 36 thousand pounds, representing about 75.2%, and 56.8% of the total variable and total costs, respectively, and thus came in the first place. The high cost of feed is due to

a large part of the feed ingredients used in the manufacture of feed is imported from abroad.

**Table No. (3): The relative importance of the average fixed and variable costs to the total costs per feddan in the study sample in 2020**

| cost items | value in pounds | % of total variable costs |
|---|---|---|
| **Fry cost** | 1532 | 3.2 |
| **Industrial feed costs** | 36000 | 75.2 |
| **Technical and regular labor costs** | 4930 | 10.3 |
| **Irrigation costs** | 2918 | 6.1 |
| **Maintenance of equipment, ponds and fishing nets** | 1485 | 3.1 |
| **Petty cash** | 1005 | 2.1 |
| **Total variable costs** | 47870 | 100 |
| **% OF total costs** | 75.5 | - |
| **Total Fixed Costs (*)** | 15530 | - |
| **% of total costs** | 24.5 | - |
| **Total costs** | 63400 | - |

(*) It is represented in the rental value of the feddan and the depreciation premium for equipment, machinery, and buildings.

**Source:** Compiled and calculated from 2020 study questionnaire data.

Followed by the costs of technical and ordinary labor, with a value of about 4.93 thousand pounds, representing about 10.3% of the total variable costs. As for other variable cost items, which are irrigation costs, equipment maintenance costs, basins, fishing nets, and petty cash, they amounted to about 2,913, 1,485, 1,005 thousand pounds, representing and to 6.1%, 3.1%, 2.1% of the total variable costs, respectively.

Table No. (3) Also shows that the average fixed costs per feddan in the study sample, which includes the depreciation premium for facilities and equipment and the rental value, amounted to about 15.53 thousand pounds, representing about 24.5% of the total costs of a feddan of fish farms.

**Third: The economies of scale for a sample of fish farms in Kafr El-Sheikh Governorate**:

**1- Standard model estimation:**

The research relied on the cubic formula of the cost function, which takes the form of the letter (U), based on economic theory. The cost function takes the following cubic form [12]:

$$TC = B_0 + B_1Q — B_2Q^2 + B_3Q^3 + U$$

**Where:**

**Tc =** total cost of production

**$Q_1$ =** Quantity of output (tons)

**U** = random variable that reflects the effect of other related variables that did not enter the model directly and that are difficult to quantify.

It is worth noting that $q^2$ is the square of the output and $q^3$ is the cube of the output and is functionally related to the variable Q, but the relationship is non-linear. Such a model satisfies the assumption that there is no multicollinearity between the independent variables since the model is non-linear in terms of the variables.

The cost function has been estimated for fish farms and the linear formula was used in estimating the model, and it was as follows:

$$TC=1509.93+36193.98Q -7680.37Q^2 + 863.76Q^3$$
$$(3.22)^{**} \quad (-2.23)^{*} \quad (2.56)^{**}$$

Adjusted $R^2$ = 0.94 F= (342.5) ** D.W= 1.78

Given the reliance of the study on cross-sectional data, it is expected that there is a problem of the instability of heteroscedasticity, as well as the problem of autocorrelation that we observe through the value of D.W, which requires addressing this problem, and it was addressed during the analysis.

After conducting statistical tests on the model, the t-test shows that the parameters ($b_1$, $b_2$, $b_3$) were significant and reliable in estimating the relationship between the total cost and the independent variables. By comparing the calculated F for the estimated function, which was 342.5, with the tabular F value, it was found that the model is highly significant, which reflects the importance of the variables included in the function on the one hand and the realism of the function on the other. Whereas, the value of the adjusted coefficient of determination $R^2$ was 0.94 in the function, which reflects the quality of the fit of the regression line, and it is clear from it that 94% of the changes in total costs are due to production, while 6% of the changes in total costs were the result of other factors that were not included in the model.

While the standard tests included the problem of autocorrelation of the random variable by adopting the Durbin-Watson test because it is suitable for testing the existence of the autocorrelation of the first degree, which showed the absence of the autocorrelation problem as its D.W value was about 1.78, which confirms the absence of this problem.

**2- Determining the optimal size of production and area for the fish farm:**

In order to be able to study the economics of the optimal scale for the production of fish farms in question, we must know the equation of the long-term average cost LR ATC, as all production costs are considered variable in the long term, and the distinction between fixed costs and variable costs in the long term fades.

The average total cost equation was derived from the total cost equation by dividing the latter by the output after excluding the fixed limit because it reflects the fixed costs. The equation of the average total costs for fish farms was as follows: -

$$LR\ ATC = 36193.98 – 7680.37Q + 863.76Q^2$$

In order to determine the optimal level of production, which is determined when the average total cost, in the long run, reaches the lowest point by applying the necessary condition for minimizing the function, this is done by taking the first derivative of the above function and setting it equal to zero, and then solving the equation in relation to Q as follows

**D ATC / d q = —7680.37 + 1727.52q = 0**
1727.52q = 7680.37
$q$ **= 7680.37/ 1727.52**
**Q = 4.445 ton / feddan**

It is clear that the optimal amount of production that minimizes costs and maximizes profit is 4.445 tons per feddan, and the optimal area can be determined by entering the area into the cost function estimation as follows [11]:

**$TC = B_0 + B_1Q - B2Q_2 + B3Q_3 + B_4 A_2 - B5QA$**
Where:
q A= the area in the volume of production
$A^2$ = the square of the area

The function was estimated and was as follows:-
**$TC=2962.72 +37850.22Q - 8086.86Q^2+914.67Q^3+ 14.24A-109.44AQ$ (3.34) ** (-2.33)* (2.66) ** (0.55) (-0.98)**
Adjusted $R^2$ =0.94 F= (207.3) ** D.W = 1.81
Taking the derivative with respect to A, the result is:
**28.48A - 109.44Q = 0**
Since q is our information, then
**28.48A = 109.44Q**
**A = 28.48/ 109.44Q**
**A= 0.2602Q**
The result is that the optimum area with low production costs is 1,156 feddan.

By finding the optimal size of production and the optimal area, we find the actual area and actual production of the sample farms through the size of the farmed area as well as the production, and the following table shows the area and the optimal and actual production quantity. Table No. (4) Shows that to obtain the optimal size, the areas of fish farms must be expanded in Kafr Sheikh Governorate.

**Table No. (4): The area and the optimum and actual production quantity for fish farms**

| statement | optimization | Actual |
|---|---|---|
| Area | 1.156 | 1 |
| Production | 4.445 | 3.118 |

**Source:** Compiled and calculated from study questionnaire data 2020.

**Recommendations:**
1- Ensure the availability of good quality fish feeds to producers at subsidized prices that are suitable for cultured fish species.
2- Provide extension service to farmers through organizing seminars during the Field Days for fish farmers in order to guide them about the recent fish farming methods as well as the best way to improve the economic efficiency of fish production.
3- Enabling farmers to achieve the optimum farm size that achieves efficiency by increasing the size of cultivated areas towards the optimal areas reached by the research.

**References:**

(GAFRD), G. A. f. F. R. D. (various issues). Fish Statistics Yearbook.

(MALR), M. o. A. a. L. R. (2019). Agricultural Income Bulletin.

Cobo, Á., Llorente, I., Luna, L., Luna, M. J. C., & Agriculture, E. i. (2019). A decision support system for fish farming using particle swarm optimization. *161*, 121-130.

El-Naggar, G., Nasr-Alla, A., & Kareem, R. (2008). Economic analysis of fish farming in Behera Governorate of Egypt.

El- Gayar, O. F. J. A. E., & Management. (2003). Aquaculture in Egypt and issues for sustainable development. *7*(1-2), 137-154.

Elhendy, A. M., Alzoom, A. A. J. A. E., & Management. (2001). Economics of fish farming in Saudi Arabia: analysis of costs of tilapia production. *5*(3-4), 229-238.

Gerald, B. J. I. J. o. A. M., & Physics, T. (2018). A brief review of independent, dependent and one sample t-test. *4*(2), 50-54.

Iversen, A., Asche, F., Hermansen, Ø., & Nystøyl, R. J. A. (2020). Production cost and competitiveness in major salmon farming countries 2003–2018. *522*, 735089.

Kaleem, O., Sabi, A.-F. B. S. J. A., & Fisheries. (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. *6*(6), 535-547.

Lin, L. J. P. o. (2018). Bias caused by sampling error in meta-analysis with small sample sizes. *13*(9), e0204056.

Pradeepkiran, J. A. J. T. A. S. (2019). Aquaculture role in global food security with nutritional value: a review. *3*(2), 903-910.

Roth, J. J. A. E. R. I. (2022). Pretest with caution: Event-study estimates after testing for parallel trends. *4*(3), 305-322.

Samarajeewa, U. J. J. O. T. N. S. F. O. S. L. (2022). Food Safety. *50*, 541.

Yuan, Y., Yuan, Y., Dai, Y., Zhang, Z., Gong, Y., & Yuan, Y. J. A. R. (2020). Technical efficiency of different farm sizes for tilapia farming in China. *51*(1), 307-315.

11/20/2022