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Economic Study of the Most Influential Variables Affecting Tomato Crop in Egypt

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Abstract: Tomatoes are considered an important food and manufacturing crop that many food industries rely on. They are grown throughout the year in Egypt. Despite the economic and nutritional importance of tomatoes, their production has decreased from about 6804 thousand tons in 2000 to about 6445 thousand tons in 2021 due to a decrease in the cultivated area from about 465 thousand acres in 2000 to about 357 thousand acres in 2021. Therefore, this research aimed to study the current situation of tomato production and consumption, as well as to predict the production, economic, and consumption indicators of the crop using the double exponential smoothing and moving average models to obtain the lowest values for the estimated criteria used in the prediction for the period from (2022-2026). The moving average model was based on three-year averages, while the double exponential smoothing model relied on suitable alpha and beta values that give the lowest error values. The research showed that the double exponential smoothing model is better than the moving average model as it gives the lowest value for all criteria used in prediction, including the mean absolute deviation (MAD), mean squared deviation (MSD), and mean absolute percentage error (MAPE). The research recommended increasing the cultivated area of the crop, whether through horizontal or vertical expansion, reducing crop loss by using proper methods of preservation and packaging, and working on deriving high-yield varieties that are resistant to pests.

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Introduction:

Tomatoes are one of the important strategic vegetable crops in Egypt, as they are food and manufacturing crops relied on by some food industries. Tomatoes are planted in Egypt in three seasons: winter, summer, and Nile. The cultivated area of tomatoes in Egypt was about 357 thousand acres in 2021, with a total production of about 6445 thousand tons, while the consumption quantity was about 6136 thousand tons, representing about 95% of the total production. The quantity of crop loss for the same year was about 1587 thousand tons, representing about 24.6% of the total production, due to the fact that tomatoes are a perishable crop. The average per capita share of the crop was about 41.5 kilograms per year in 2021, while the surplus quantity of tomatoes was about 309 thousand tons. The quantity of exports was about 324 thousand tons for the same year, while the amount remaining as human food amounted to about 4549 thousand tons in 2021.

Research Problem:

Despite the increase in the yield per acre of tomato crop, the total production of the crop has decreased from about 6785 thousand tons in 2000 to about 6389 thousand tons in 2021 due to a decrease in the cultivated area from about 465 the yield per acre for the tomato crop in Egypt thousand acres in 2000 to about 357 thousand acres in 2021. This led to studying the factors affecting the production and consumption of the crop and predicting them to meet the increasing nutritional needs of the crop and directing a larger quantity of it for export.

Objectives:

The main objective of the research is to study the current situation of tomato production and consumption in Egypt and the future expectations of the most relevant variables related to the crop. To achieve this, the following sub-objectives were studied:

First: The development of production indicators for tomatoes in Egypt during the period (2000-2021).

Second: The development of economic indicators for the crop during the period (2000-2021).

Third: The development of consumption indicators for the crop during the period (2000-2021).

Fourth: The study of the economic relationships of the most relevant variables related to the tomato crop in Egypt during the period (2000-2021).

Fifth: Statistical forecasting of productivity, economic, and consumption indicators using the double exponential smoothing and moving average models to reach the lowest values of the estimated standards used in forecasting.

Methodology:

To achieve the research objectives, descriptive and quantitative analysis methods were used, represented in some simple and multiple statistical methods and models to estimate the linear regression of the production, economic and consumption variables of the tomato crop under study, as well as to estimate the statistical forecasting of productivity, economic and consumption indicators using the double exponential smoothing and moving average models.

Data sources:

The research relied on published and unpublished data from the Ministry of Agriculture and Land Reclamation, the Economic Affairs sector, by using different numbers published in agricultural statistics, the food balance sheet, cost statistics, net return statistics for agricultural crops, and the Central Agency for Public Mobilization and Statistics, in addition to some related research, theses, and scientific journals.

Results:

Firstly: Development of productivity indicators for the tomato crop in Egypt during the period (2000-2021).

1- Development of the area planted with tomato crop in Egypt during the period (2000-2021):

The data in Table (1) in the appendix indicates the development of the area planted with the tomato crop in Egypt during the period (2000-2021), where it was found that the area planted with the crop varied during the study period between a minimum of approximately 357 thousand acres in 2021 and a maximum of approximately 600 thousand acres in 2009, with an annual average of approximately 473 thousand acres during the study period.

By estimating the time trend equation in Table (1), it was found that the area planted with tomatoes has taken a statistically significant decreasing trend at a level of 0.05, estimated at about 4.256 thousand acres per year, a decrease of about 0.90% from the average area planted with tomatoes. The coefficient of determination (R^2) indicates that about 20% of the variations in the area planted with the tomato crop are attributed to the factor of time, and the rest are attributed to other factors not included in the equation.

2- The development of the acre yield of the tomato crop in Egypt during the period (2000-2021)

The data in Table (1) in the appendix indicates the yield per acre for the tomato crop in Egypt during the period (2000-2021), where it was found that the yield per acre for the crop varied during the study period between a minimum of approximately 14.59 tons per acre in 2000 and a maximum of approximately 17.90 tons per acre in 2021, with an annual average of approximately 16.32 tons per acre.

By estimating the time trend equation in Table (1) for the yield per acre of tomatoes, it was found that it has taken a statistically significant increasing trend at a level of 0.01, estimated at about 0.092 tons per acre per year, or about 0.56% of the average yield per acre. The coefficient of determination (R^2) indicates that about 54% of the variations in the yield per acre of the tomato crop are attributed to the factor of time, and the rest are attributed to other factors not included in the equation.

3- Production development of the tomato crop in Egypt during the period (2000-2021):

The data in Table (1) in the appendix indicates the production of the tomato crop in Egypt during the period (2000-2021), where it was found that the production varied during the study period between a minimum of approximately 6328.7 thousand tons in 2001 and a maximum of approximately 10278.5 thousand tons in 2009, with an annual average of approximately 7712 thousand tons.

By estimating the time trend equation in Table (1) for the production of the tomato crop, it was found that it has taken a non-significant decreasing trend at any of the probability levels.

Secondly: The economic indicators of the tomato crop in Egypt during the period (2000-2021).

1- Development of the farm price of the tomato crop in Egypt during the period (2000-2021):

The data in Table (2) in the appendix show the development of the farm price of the tomato crop in Egypt during the period (2000-2021). The lowest farm price reached about 0.372 thousand pounds per ton in 2001, and the highest was about 3.356 thousand pounds per ton in 2021, with an annual average of about 1.117 thousand pounds per ton.

By estimating the trend equation of the farm price of tomatoes in Table (2), it is shown that it took a statistically significant increasing trend at the 0.01 level, at about 0.097 thousand pounds per ton, equivalent to about 8.68% of the average farm price. The coefficient of determination (R^2) indicates that about 79% of the changes in the price of the tomato crop are due to the time factor and the rest is due to other factors not included in the equation.

Table (1): The average annual time trend rates for the productivity indicators of the tomato crop in Egypt during the period (2000-2021).

Phenomenon	Equation	Average	Growth Rate %	R^2	F
Cultivated area (1000 acres)	$\hat{Y}_{1i} = 521.793 - 4.256\ X_i$ $(2.269)^*$	473	0.90-	0.20	5.15
Yield per acre (tons/acre)	$\hat{Y}_{2i} = 15.267 + 0.092\ X_i$ $(4.825)^{**}$	16.32	0.56	0.54	23.3
Production (1000 tons)	$\hat{Y}_{3i} = 8068.461 - 30.953\ X_i$ $(0.873)^-$	7712	0.40-	0.04	0.76

Where:
$\hat{Y}_{1i}$ = Estimated value of the cultivated area of the crop tomatoes in thousand acres per year i.
$\hat{Y}_{2i}$ = Estimated value of the yield per acre of the crop tomatoes in tons per acre per year i.
$\hat{Y}_{3i}$ = Estimated value of the total production of the crop tomatoes in thousand tons per year i.
X_i = Time variable, i = 1, 2, 3, ..., 22. (R^2) Coefficient of determination.
(*) Indicates statistical significance of the regression model at the 0.05 level.
(**) Indicates statistical significance of the regression model at the 0.01 level.
(-) Not significant. The value in parentheses indicates the calculated (T).
Source: Compiled and calculated from Table (1) in the appendix.

2- Development of consumer prices for the tomato crop in Egypt during the period (2000-2021):

The data in Table (2) in the appendix indicate the development of consumer prices for the tomato crop in Egypt during the period (2000-2021). The prices fluctuated during the study period, with a minimum of about 0.848 thousand pounds per ton in 2001 and a maximum of about 6.000 thousand pounds per ton in 2021, with an annual average of about 2.449 thousand pounds per ton.

By estimating the trend equation of consumer prices for tomatoes in Table (2), it is shown that it took a statistically significant increasing trend at the 0.01 level, at about 0.208 thousand pounds per ton per year, equivalent to about 8.49% of the average consumer price. The coefficient of determination (R^2) indicates that about 81% of the changes in consumer prices for tomatoes are due to the time factor and the rest is due to other factors not included in the equation.

3- Development of total costs for the tomato crop in Egypt during the period (2000-2021):

The data in Table (2) in the appendix indicate the development of total costs for the tomato crop in Egypt during the period (2000-2021). The lowest cost reached about 2.602 thousand pounds in 2000, and the highest was about 23.399 thousand pounds in 2021, with an annual average of about 6.025 thousand pounds.

By estimating the trend equation of total costs for tomatoes in Table (2), it is shown that it took a statistically significant increasing trend at the 0.01 level, at about 0.568 thousand pounds, equivalent to about 9.43% of the average cost. The coefficient of determination (R^2) indicates that about 61% of the changes in the cost of the tomato crop are due to the time factor and the rest is due to other factors not included in the equation.

Table (2): Trend equations for the economic indicators of the tomato crop during the period (2000-2021).

Phenomenon	Equation	Average	Growth Rate %	R^2	F
Farm price (1000 EGP/ton)	$\hat{Y}_{1i} = -0.002 + 0.097X_i$ $(8.78)^{**}$	1.117	8.68	0.79	77.2
Consumer price (1000EGP/ton)	$\hat{Y}_{2i} = 0.051 + 0.208\ X_i$ $(9.21)^{**}$	2.449	8.49	0.81	84.81
Total costs (1000 EGP)	$\hat{Y}_{3i} = -0.511 + 0.568X_i$ $(5.56)^{**}$	6.025	9.43	0.61	30.9
Net returns (1000 EGP)	$\hat{Y}_{4i} = -.0017 + 1.159\ X_i$ $(11.34)^{**}$	13.308	8.71	0.86	128.5

Where:
$\hat{Y}_{1i}$ = Estimated value of the farm price of the tomatoes in thousands of Egyptian pounds per ton in year i.
$\hat{Y}_{2i}$ = Estimated value of the consumer price of the tomatoes in thousands of Egyptian pounds per ton in year i.
$\hat{Y}_{3i}$ = Estimated value of the total costs of the tomatoes in thousands of Egyptian pounds in year i.
$\hat{Y}_{4i}$ = Estimated value of the net return for the crop tomatoes in thousands of Egyptian pounds in year i.
X_i = Time variable, i.e. h = 1, 2, 3, ..., 22.

(R^2) indicates the coefficient of determination.
(**) indicates the significance of the regression model at a 0.01 level, and the value in parentheses indicates the calculated (T).
Source: Compiled and calculated from data in Table (2) in the appendix.

4. Development of net returns for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (2) in the appendix indicate the evolution of the net returns for the tomato crop in Egypt during the period (2000-2021). The data show that the minimum value was about 3.283 thousand pounds in 2001, while the maximum value was about 33.855 thousand pounds in 2021, with an average annual value of about 13.308 thousand pounds.

By estimating the time trend equation using the data in Table (2), it is shown that the net returns for the tomato crop have taken a statistically significant increasing trend at a 0.01 level, with an estimated increase of about 1.159 thousand pounds, which is equivalent to about 8.71% of the average net return. The coefficient of determination (R^2) value indicates that about 86% of the variations in net returns for the crop are attributable to the time factor, while the remaining factors are not included in the equation.

Thirdly: Evolution of consumption indicators for the tomato crop in Egypt during the period (2000-2021):

1. Evolution of total production for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of total production for the tomato crop in Egypt during the period from 2000 to 2021. The data show that the quantity of production has fluctuated during the study period, with a minimum of about 6338 thousand tons in 2001 and a maximum of about 10334 thousand tons in 2009, with an average annual value of about 7752 thousand tons.

By estimating the time trend equation using the data in Table (3), it is shown that the total production for the tomato crop has taken a statistically insignificant decreasing trend at both levels of significance.

2. Evolution of imports for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of imports for the tomato crop in Egypt during the period from 2000 to 2021. The data show that the quantity of imports has fluctuated during the study period, with a minimum of about thousand tons in 2001, 2002, 2003, 2004, and 2018, and a maximum of about 49 thousand tons in 2011, with an average annual value of about 11.5 thousand tons.

By estimating the time trend equation using the data in Table (3), it is shown that the imports for the tomato crop have taken a statistically significant increasing trend at a 0.05 level, with an estimated increase of about 0.75 thousand tons per year, which is equivalent to about 6.52% of the average imports. The coefficient of determination (R^2) value indicates that about 19% of the variations in the quantity of imports for the crop are attributable to the time factor, while the remaining factors are not included in the equation.

3. Evolution of availability for consumption for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of availability for consumption for the tomato crop in Egypt during the period from 2000 to 2021. The data show that the quantity of availability has fluctuated during the study period, with a minimum of about 6136 thousand tons in 2021 and a maximum of about 10212 thousand tons in 2009, with an average annual value of about 7624 thousand tons.

By estimating the time trend equation using the data in Table (3), it is shown that the availability for consumption for the tomato crop has taken a statistically insignificant decreasing trend at both levels of significance.

4. Evolution of exports for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of exports for the tomato crop in Egypt during the period from 2000 to 2021. The data show that the quantity of exports has fluctuated during the study period, with a minimum of about 4 thousand tons in 2003 and a maximum of about 324 thousand tons in 2021, with an average annual value of about 139 thousand tons.

By estimating the time trend equation using the data in Table (3), it is shown that the exports for the tomato crop have taken a statistically significant increasing trend at a 0.01 level, with an estimated increase of about 17.84 thousand tons per year, which is equivalent to about 12.83% of the average annual exports. The coefficient of determination (R^2) value indicates that about 92% of the variations in the quantity of exports for the crop are attributable to the time factor, while the remaining factors are not included in the equation.

5. Evolution of losses for the tomato crop in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of losses for the tomato crop in Egypt during the period from 2000 to 2021. The data show that the quantity of losses has fluctuated during the study period, with a minimum of about 634 thousand tons in 2001 and a maximum of about 2553 thousand tons in 2009, with an average annual value of about 1648 thousand tons.

By estimating the time trend equation using the data in Table (3), it is shown that the losses for the tomato crop have taken a statistically significant increasing trend at a 0.01 level, with an estimated increase of about 65.07 thousand tons per year, which is equivalent to about 3.95% of the average annual losses. The coefficient of determination (R^2) value indicates that about 43% of the variations in the quantity of losses for the crop are attributable to the time factor, while the remaining factors are not included in the equation.

Table (3): Time Trend Equations for Tomato Crop Consumption Indicators during the period (2000-2021)

	Phenomenon	Equation	Average	Growth Rate %	R^2	F
1	Total production	$\hat{Y}_{1i} = 8112.88 - 31.37 X_i$ $(0.87)^{-}$	7752	-0.40	0.04	0.76
2	Imports	$\hat{Y}_{2i} = 2.79 + 0.75 X_i$ $(2.16)^{*}$	11.5	6.52	0.19	4.66
3	Available for consumption	$\hat{Y}_{3i} = 8180.60 – 48.46 X_i$ $(1.32)^{-}$	7624	-0.63	0.08	1.75
4	Exports	$\hat{Y}_{4i} = - 65.96 + 17.84 X_i$ $(9.21)^{**}$	139	12.83	0.92	235
5	Loss	$\hat{Y}_{5i} = 900.08 + 65.07 X_i$ $(3.90)^{**}$	1648	3.95	0.43	15.23
6	Remaining as food for humans	$\hat{Y}_{6i\ i} = 7281.56 – 113.53 X_i$ $(4.75)^{**}$	5976	-1.90	0.53	22.60
7	Average per capita share	$\hat{Y}_{7i} = 94.55 - 2.27 X_i$ $(6.66)^{**}$	68.4	-3.32	0.69	44.42
8	Surplus or deficit	$\hat{Y}_{9i} = - 67.71 + 16.92 X_i$ $(13.42)^{**}$	127	13.32	0.90	180

Where:
$\hat{Y}_{1i}$ = Estimated value of tomato crop total production in thousands of tons for year i.
$\hat{Y}_{2i}$ = Estimated value of tomato crop imports in thousands of tons for year i.
$\hat{Y}_{3i}$ = Estimated value of tomato crop availability for consumption in thousands of tons for year i.
$\hat{Y}_{4i}$ = Estimated value of tomato crop exports in thousands of tons for year i.
$\hat{Y}_{5i}$ = Estimated value of tomato crop losses in thousands of tons for year i.
$\hat{Y}_{6i}$ = Estimated value of tomato crop remaining tomato crop as human food in thousands of tons for year i.
$\hat{Y}_{7i}$ = Estimated value of average per capita share in kilograms for year i.
$\hat{Y}_{8i}$ = Estimated value of tomato crop surplus or deficit in thousands of tons for year i.
X_i = Time variable, i.e., h = 1, 2, 3, ..., 22. (R^2) Coefficient of determination.
(**) Indicates significant regression model coefficients at a 0.01 level of significance.
(*) Indicates significant regression model coefficients at a 0.05 level of significance.
- Indicates not significant.
The value in parentheses indicates the calculated t-value.
Source: Compiled and calculated from data in Table (3).

6- Evolution of remaining tomato crop as human food in Egypt during the period (2000-2021):

The data presented in Table (3) in the appendix indicate the evolution of the remaining quantity of tomato crop as human food in Egypt. The data show that the quantity of available food has fluctuated during the study period, with a minimum of about 4519 thousand tons in 2020 and a maximum of about 7659 thousand tons in 2009, with an average annual value of about 5976 thousand tons.

By estimating the time trend equation in Table (4) for the remaining quantity of tomato crop as human food, it was found that it has taken a statistically significant decreasing trend at the 0.01 level of significance, with a magnitude of approximately 113.53 thousand tons per year, or about 1.90% of the average. The value of the coefficient of determination (R^2) indicates that about 53% of the variation in the remaining quantity of tomato crop as human food is attributable to the time factor, while the remaining factors are not included in the equation.

7- Evolution of per capita tomato crop share in Egypt during the period (2000-2021):

The data in Table (3) in the appendix indicate that the per capita tomato crop share has shown fluctuation during the study period, with a minimum of about 41.5 kg/year in 2021 and a maximum of about 95.1 kg/year in 2006, with an annual average of about 68.4 kg/year.

By estimating the time trend equation in Table (3), it is found that it has taken a statistically significant decreasing trend at the 0.01 level of significance, with a magnitude of approximately 2.27 kg/year or about 3.33% of the average. The value of the coefficient of determination (R^2) indicates that about 69% of the variation in the per capita tomato crop share is attributable to the time factor, while the remaining factors are not included in the equation.

8- Evolution of tomato crop surplus or deficit in Egypt during the period (2000-2021):

The data in Table (3) in the appendix indicate the evolution of tomato crop surplus or deficit in Egypt during the period (2000-2021), where a deficit of about 2 thousand tons was recorded in 2000, while a surplus was recorded in the remaining years of the study period, with a minimum of about 3 thousand tons in 2003 and a maximum of about 309 thousand tons in 2021, with an annual average of about 127 thousand tons.

By estimating the time trend equation in Table (3), it is found that it has taken a statistically significant increasing trend at the 0.01 level of significance, with a magnitude of approximately 16.92 thousand tons per year, or about 13.32% of the average. The value of the coefficient of determination (R^2) indicates that about 90% of the variation in the tomato crop surplus or deficit is attributable to the time factor, while the remaining factors are not included in the equation.

Fourthly: Studying the economic relationships of the most important variables related to tomato crop in Egypt during the period (2000-2021).

The area, production, farm price, net return, productivity, availability for consumption, and consumer price are among the influential factors in making decisions at both individual and national levels to encourage farmers to expand the cultivation of the crop. Therefore, the following economic relationships were studied to demonstrate the impact of both the area and net return with a lagged period on production, as it became clear that they were the most influential variables on production during the study period. Furthermore, the impact of both per-acre productivity and farm price on net return was studied, as it was found that they were the most influential variables on net return per acre during the study period. Additionally, the impact of production and consumer price on availability for consumption was studied as they were found to be the most influential variables on availability for consumption during the study period. From the study of the previous relationships, the following can be

1. Analyzing the relationship between production and both the area and net return per acre:

It became clear from studying the relationship between tomato crop production as a dependent variable and both the cultivated area and net return for the previous year as independent variables, as shown in Table (4) during the period (2000-2021), that there is a positive relationship between production and both the area for the current year and net return per acre with a lagged period. The regression coefficients indicated that an increase in the area by one thousand acres leads to an increase in tomato crop production by about 18.13 thousand tons. The statistical significance of the regression coefficient was confirmed at a level of 0.01. Similarly, an increase in net return per acre for the previous year by one thousand Egyptian pounds leads to an increase in production of the crop by about 40.82 thousand tons. The statistical significance of the regression coefficient was also confirmed at a level of 0.01. The determination coefficient value indicated that 94% of the variations in production can be attributed to the variations in the area and net return per acre with a lagged period.

2- Analysis of the relationship between net return per acre and both productivity per acre and farm price:

Table (4) shows the relationship between net return per acre and both productivity per acre and farm price for tomato crop during the period (2000-2021). The results obtained from equation (2) indicate a positive relationship between productivity per acre and net return per acre. The regression coefficients indicate that an increase in productivity per acre by one ton leads to an increase in net return for tomato crop by approximately 0.7 thousand pounds. However, the statistical significance of the regression coefficients was not confirmed at either the 0.05 or 0.01 levels of probability. There is also a positive relationship between farm price and net return, where an increase in farm price by one thousand pounds leads to an increase in net return for the crop by approximately 10.61 thousand pounds. The statistical significance of the regression coefficients was confirmed at the 0.01 level. The coefficient of determination indicates that 96% of the variations in net return can be attributed to variations in productivity and farm price for the crop.

Table (4): Estimating the regression relationship of the most influential variables on tomato crop during the period (2000-2021)

Phenomenon	Equation	Average	Growth Rate %	R^2
Production and both area and net returns	$\hat{Y}_{1i} = -1346.46 + 18.13\ X_{1i} + 40.82 X_{2i-1}$ $(17.17)^{**}\quad(4.40\ )^{**}$	0.94	152.9	**
Net returns and both productivity per acre and farm price	$\hat{Y}_{2i} = -10.01 + 0.70\ X_{3i} + 10.61\ X_{4i}$ $(1.12)^{-}\quad(14.84)^{**}$	0.96	222.6	**
Available for consumption and both production and consumer price	$\hat{Y}_{3i} = 3.72 + 1.01\ X_{5i} – 0.06\ X_{6i}$ $(56.55)^{**}\quad(5.22)^{**}$	0.99	3053	**

Where:
$\hat{Y}_{1i}$ = Estimated value of tomato production in thousands of tons in year i.
$\hat{Y}_{2i}$ = Estimated value of net return of tomato crop in thousands of pounds in year i.
$\hat{Y}_{3i}$ = Estimated value of tomato crop availability for consumption in thousands of tons in year i.
X_{1i} = Estimated value of tomato crop area in thousands of acres in year i.
X_{2i-1}= Estimated value of net return with lagged period of tomato crop in thousands of pounds in year i.
X_{3i} = Estimated value of tomato crop productivity in tons per acre in year i.
X_{4i} = Estimated value of farm price of tomato crop in thousands of pounds in year i.
X_{5i} = Estimated value of tomato crop production in thousands of tons in year i.
X_{6i} = Estimated value of consumer price of tomato crop in thousands of pounds in year i.
(R^2) indicates the coefficient of determination.
(-) indicates non-significance at both the 0.05 and 0.01 levels of statistical significance.
(**) indicates significant coefficients of the regression model at the 0.01 level.
The value in parentheses indicates the calculated t-value.
Source: Compiled and calculated from data in tables (1) , (2) and (3) in the appendix.

3- Analysis of the relationship between availability for consumption and both production and consumer price:

Table (4) shows the regression relationship between availability for consumption and both production and consumer price for tomato crop during the period (2000-2021). The results obtained from equation (3) indicate a positive relationship between production and availability for consumption. The regression coefficients indicate that an increase in production by one thousand tons leads to an increase in availability for consumption by approximately 1.01 thousand tons. The statistical significance of the regression coefficient was confirmed at the 0.01 level. There is also a negative relationship between consumer price and availability for consumption. An increase in consumer price by one thousand pounds leads to a decrease in consumption by approximately 0.06 thousand tons. The statistical significance of the regression coefficient was confirmed at the 0.01 level. The coefficient of determination indicates that 99% of the variations in availability for consumption can be attributed to variations in production and consumer price for the crop during the study period.

Fifthly: Statistical forecasting of production, economic and consumption indicators for tomato crops using the double seasonal exponential smoothing and moving average models.

The double exponential smoothing and moving average models are forecasting models aimed at reducing the variations in the values of the time series around the curve that represents the overall pattern of the series. The moving average model is a series of arithmetic averages of successive values from the series that move along the time of the series to form a new series. The moving average takes a three-year average to find new period data and uses this average to forecast the next period. However, due to some drawbacks of this model, such as the need for a large amount of data, the smoothing or double exponential smoothing model is used, which is better than the moving average model. It depends on all values as all values of the series participate in the prediction. It is characterized by its ease of application, speed of obtaining results, and giving the lowest value of error. It also depends on estimating the model coefficients α and β, which range from zero to one. The closer the value of α is to zero, the more significant the model values are.

The evaluation criteria for the models are:
- Mean Absolute Deviation (MAD)
- Mean Square Deviation (MSD)
- Mean Absolute Percentage Error (MAPE)

A) Forecasting tomato crop production indicators during the period) 2022-2026).

By forecasting the area, productivity, and production using the moving average and double exponential smoothing models, it was shown from table (5) that the suitable alpha values for the smoothing model were (1) for the area, (0.8) for productivity, and (1) for production. The suitable beta values were (0.3) for the area, (0) for productivity, and (0.2) for production. This gave the lowest values for all evaluation criteria (MAD, MSD, and MAPE) for the area, productivity, and production when compared to the moving average model. The double exponential smoothing model was the best in terms of estimated criteria values, which gave the lowest values for all used criteria compared to the moving average model, as shown in table (5). The moving average period was three years, while the forecasting period was five years.

By forecasting the tomato crop during the period (2022-2026), as shown in table (6), it was found that the area forecasted using the moving average model was about 368, 357, 369, 365, and 364 thousand acres, respectively. While using the double exponential smoothing, the area forecasted was about 339, 321, 303, 285, and 267 thousand acres, respectively, after removing the trend and seasonal effects from the values forecasted in the smoothing model. The forecasted productivity values using the moving average model were about 17.50, 17.90, 17.53, 17.64, and 17.69 tons per acre, respectively, for the same period. While using the double exponential smoothing, the forecasted productivity values were about 17.87, 17.99, 18.11, 18.23, and 18.35 tons per acre, respectively, for the same period. The forecasted production values were about 6440, 6390, 6469, 6438, and 6439 thousand tons, respectively, for the moving average model. While using the double exponential smoothing, the forecasted production values were about 6058, 5775, 5487, 5195, and 4899 thousand tons, respectively, for the period (2022-2026).

Table (5): Estimating the parameters of the moving average and double exponential smoothing models for the cultivated area, productivity and production indicators.

Items	moving average			double exponential smoothing		
	Cultivated area	Productivity	Production	Cultivated area	Productivity	Production
MAD	36368	0.526	649824	23437	0.492	451023
MSD	1.645	0.461	5.826	1.074	0.324	3.516
MAPE	7.677	3.156	8.119	4.998	2.973	5.653
α				1	0.8	1
β				0.3	0.0	0.2
Result	Gives higher error values			gives lower error values		
Decision	double exponential smoothing is better than moving average					
Number of years for the average	3					
Number of years for the forecast	5			5		

Source: Compiled and calculated from data in table (1) in the appendix.

Table (6): Forecasting values for the area, productivity and production indicators for the period of 2022-2026.

Forecast year	moving average			double exponential smoothing		
	Cultivated area (1000 acres)	Productivity (tons/acre)	Production (1000 tons)	Cultivated area (1000 acres)	Productivity (tons/acre)	Production (1000 tons)
2022	368	17.50	6440	339	17.87	6058
2023	357	17.90	6390	321	17.99	5775
2024	369	17.53	6469	303	18.11	5487
2025	365	17.64	6438	285	18.23	5195
2026	364	17.69	6439	267	18.35	4899

Source: Compiled and calculated from data in table (1) in the appendix.

B) Forecasting the economic indicators for tomato crop during the period 2022-2026.

By forecasting the farm price, total costs, and net return using the moving average and double exponential smoothing models, it was shown from table (7) that the double exponential smoothing model was better than the moving average model. The suitable alpha values for the smoothing model were (1) for the farm price, (1) for the total costs, and (1) for the net return. The suitable beta values were (0.7) for the farm price, (1) for the total costs, and (0.1) for the net return. This gave the lowest values for all evaluation criteria (MAD, MSD, and MAPE) for the farm price, total costs, and net return when compared to the moving average model.

Table (7): Estimating the parameters of the moving average and double exponential smoothing models for the farm price indicators, total costs, and net return.

Items	moving average			double exponential smoothing		
	Farm price	Total costs	Net returns	Farm price	Total costs	Net returns
MAD	0.244	1.545	2.836	0.176	0.993	2.169
MSD	0.184	9.945	19.865	0.115	6.962	11.380
MAPE	17.072	16.100	18.712	12.839	9.193	14.945
α				1	1	1
β				0.7	1	0.1
Result	Gives higher error values			gives lower error values		
Decision	double exponential smoothing is better than moving average					
Number of years for the average	3					
Number of years for the forecast	5			5		

Source: Compiled and calculated from data in table (2) in the appendix.

Table (8): Forecasting value for the farm prices, total costs, and net returns for the period (2022-2026).

Forecast year	moving average			double exponential smoothing		
	Farm price (1000 EGP)	Total costs (1000 EGP)	Net returns (1000 EGP)	Farm price (1000 EGP)	Total costs (1000 EGP)	Net returns (1000 EGP)
2022	2.695	17.543	29.620	4.339	35.110	42.428
2023	3.356	23.399	36.673	5.322	46.821	48.922
2024	2.799	18.709	30.357	6.305	58.532	55.651
2025	2.950	19.884	32.154	7.288	70.243	62.617
2026	3.035	20.664	33.025	8.271	81.954	69.819

Source: Compiled and calculated from data in table (2) in the appendix.

By forecasting the tomato crop during the period (2022-2026), as shown in table (8), it was found that the farm price forecasted using the moving average model was about 2.695, ،3.356, 2.799,2.950, and 3.035 thousand pounds respectively. While using the double exponential smoothing, the farm price forecasted was about 4.339, 5.322, 6.305, 7.288, and 8.271 thousand pounds respectively, after removing the trend and seasonal effects from the values forecasted in the double exponential smoothing model. The forecasted total costs values using the moving average model were about 17.543, 23.399, 18.709 19.884, and 20.664thousand pounds, respectively, for the same period. While using the double exponential smoothing, the forecasted total costs values were about 35.110, 46.821, 58.532, 70.243, and 81.954 thousand pounds, respectively, for the same period. The forecasted net return values were about 29.6205, 36.673, 30.357, 32.154, and33.025 thousand pounds, respectively, for the moving average model. While using the double exponential smoothing, the forecasted net return values were about 42.428, 48.922, 55.651, 62.617, and 69.819 thousand pounds, respectively, for the period (2022-2026).

C- Forecasting of consumption indicators for the tomato crop during the period (2022-2026).

By conducting a forecast for both availability for consumption and exports using the moving average and double exponential smoothing models as shown in Table (9), it appears that the double exponential smoothing model was better than the moving average model. The appropriate alpha value were (1) for availability for consumption and (1) for exports while the suitable beta values were (0.2) for availability for consumption and (0.1) for exports which gave lower values for all criteria used in the double exponential smoothing model for each of the mean absolute deviation (MAD), mean squared deviation (MSD), and mean absolute percentage error (MAPE) for availability for consumption and exports, compared to the moving average and double exponential smoothing models for the tomato crop, as shown in Table (9).

By conducting a forecast for the quantity available for consumption and exports of the tomato crop during the period (2022-2026) as shown in Table (10), it appears that the quantity available for consumption in the moving average model was about 6172, 6136, 6201, 6170, 6169 thousand tons, respectively, for the period (2022-2026), while it was about 5950, 5763, 5577, 5390, 5204 thousand tons, respectively, in the double exponential smoothing model for the same period. The predicted values for the quantity of exports were about 315, 324, 316, 318, 319 thousand tons, respectively, for the moving average model, while they were about 338, 352, 366, 380, 394 thousand tons, respectively, for the double exponential smoothing model for the same period.

Table (9): Estimating the parameters of the Moving Average and double exponential smoothing models for available for consumption and export indicators.

Items	moving average		double exponential smoothing	
	Available for consumption	Exports	Available for consumption	Exports
MAD	672.474	38.175	445.429	25.762
MSD	5.848	2.571	3.305	1.335
MAPE	8.529	35.256	5.651	34.739
α			1	1
β			0.2	0.1
Result	Gives higher error values		gives lower error values	
Decision	double exponential smoothing is better than moving average			
Number of years for the average	3			
Number of years for the forecast	5		5	

Source: Compiled and calculated from data in table (3) in the appendix.

Table (10): Forecasting the values available for consumption, and exports for the period (2022-2026).

Forecast year	Forecast with the moving average		Forecast double exponential smoothing	
	Available for consumption (1000 tons)	Exports (1000 tons)	Available for consumption (1000 tons)	Exports (1000 tons)
2022	6172	315	5950	338
2023	6136	324	5763	352
2024	6201	316	5577	366
2025	6170	318	5390	380
2026	6169	319	5204	394

Source: Compiled and calculated from data in Table (3) in the appendix.

Summary:

The problem addressed in this research is the decrease in the total production of tomatoes due to the decrease in the cultivated area. This led to the study of the factors affecting production and consumption, and their prediction to meet the increasing food needs during the study period (2000-2021). The research aimed to study the current situation of tomato production and consumption in Egypt, and the future expectations of the most important variables related to the crop. The research used the Moving Average and Double Exponential Smoothing models to predict productivity, economic and consumption indicators and to reach the lowest estimated values. The study relied mainly on published and unpublished data, such as bulletins issued by the Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation during the period (2000-2021), as well as some related research and studies.

The results showed that the annual increase in productivity, farm price, consumer price, costs, net return, loss, imports, exports, surplus or deficit of tomatoes reached about 0.092 tons per feddans, 0.097 thousand pounds per ton, 0.208 thousand pound per ton, 0.568 thousand pound, 1.159 thousand pound, 65.072 thousand tons, 0.753 thousand tons, 17.842 thousand tons, 16.9 thousand tons, respectively. Meanwhile, the area, production, available for consumption, remaining as human food, and per capita average share decreased by about 4.256 thousand feddans, 30.953 thousand tons, 48.46 thousand tons, 113.53 thousand tons, and 2.27 kilograms per year, respectively, during the period (2000-2021).

Studying the relationship between production and both the area for the current year and net return per acre with a lagged period .showed that an increase in the area by one thousand feddans leads to an increase in tomato production by about 18.13 thousand tons, while an increase in net return with a lagged period by one thousand pounds leads to an increase in production by about 40.82 thousand tons. The relationship between net return and both productivity and farm price indicated that an increase in productivity by one ton per feddans leads to an increase in net return by about 0.70 thousand pound, while an increase in farm price by one thousand pounds leads to an increase in net return by about 10.61 thousand pound. The relationship between available for consumption and both production and consumer price showed a direct relationship between available for consumption and production, where an increase in production by one thousand tons leads to an increase in available for consumption by about 1.01 thousand tons, while an increase in consumer price by one thousand pound per ton leads to a decrease in available for consumption by about 0.06 thousand tons.

Using the Moving Average and Double Exponential Smoothing models to predict productivity, economic, and consumption indicators for the tomato crop for the period (2022-2026), the Moving Average model relied on the average number of years, which was three years, while the Double Exponential Smoothing model relied on the appropriate values of alpha and beta, which give the lowest error values. The Double Exponential Smoothing model was found to be better than the Moving Average model as it gave the lowest values for all the criteria used in prediction, including Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD), and Mean Absolute Percentage Error (MAPE).

Recommendations:

1. Increase the cultivated area of tomatoes, either by horizontal expansion by increasing the cultivated area or vertical expansion by loading the crop on some suitable crops.
2. Develop high-yielding varieties that are resistant to pests to increase the quantity of production from the crop.
3. Work on reducing the loss of the crop by using proper methods of preservation and packaging because tomatoes are considered a perishable crop.
4. Use the export-oriented farming method to increase the quantity of exports of the crop, thus providing foreign currency.
5. Activate the role of contract farming in increasing the quantity of production of tomatoes by providing a guaranteed price for the crop, which encourages farmers to cultivate it and thus increase its production.
6. Activate the role of agricultural guidance in directing farmers towards ways to reduce the loss of the crop, which increases production and therefore the income of the farmer.

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Appendices

Table (1) Productivity indicators of tomato crop during the period (2000-2021).

Years	Cultivated Area (1000 acres)	Yield per Acre (ton/acre)	Production (1000 tons).
2000	465	**14.59**	6786
2001	430	14.71	**6329**
2002	455	14.90	6778
2003	459	15.55	7140
2004	464	16.45	7641
2005	495	16.94	8391
2006	524	16.36	8576
2007	537	16.08	8639
2008	572	16.10	9204
2009	**600**	17.14	**10278**
2010	515	16.59	8545
2011	506	15.92	8054
2012	515	16.64	8571
2013	489	16.92	8269
2014	510	16.22	8264
2015	468	16.49	7727
2016	440	16.61	7311
2017	396	17.00	6723
2018	416	16.27	6771
2019	409	16.62	6794
2020	380	17.09	6494
2021	**357**	**17.90**	6389
Average	**473**	**16.32**	**7712**

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Agricultural Statistics Bulletins, various issues.

Table (2) Economic indicators of tomato crop in Egypt during the period (2000-2021).

Years	Farm Price (1000 EGP/ton)	Consumer Prices (1000EGP/ton)	Total Costs (1000 EGP)	Net Returns in (1000 EGP)
2000	0.388	1.140	**2.602**	3.385
2001	**0.372**	**0.848**	2.633	**3.283**
2002	0.383	0.930	2.703	3.300
2003	0.449	1.070	2.904	4.689
2004	0.514	1.150	3.134	5.931
2005	0.523	1.010	3.298	6.132
2006	0.639	1.490	3.270	7.831
2007	0.601	1.250	3.389	6.957
2008	0.810	1.970	3.901	10.065
2009	0.651	1.270	4.056	8.039
2010	0.918	2.620	4.205	10.871
2011	1.452	2.770	4.312	19.714
2012	1.301	2.500	4.551	17.793
2013	1.308	2.140	4.887	17.565
2014	1.313	2.330	5.297	17.118
2015	1.340	3.040	5.743	17.318
2016	1.400	2.610	7.573	17.113
2017	1.562	3.330	8.552	19.876
2018	1.614	5.485	9.976	18.130
2019	1.646	4.460	10.469	18.819
2020	2.033	4.470	11.688	24.994
2021	**3.356**	**6.000**	**23.399**	**33.855**
Average	**1.117**	**2.449**	**6.025**	**13.308**

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Cost and Net Return Statistics Bulletins, various issues.

Table (3) Consumption indicators of tomato crop in Egypt during the period (2000-2021).

Years	Total Production* (1000 tons).	Imports (1000 tons)	Available for Consumption (1000 tons)	Exports (1000 tons)	Loss (1000 tons)	Remaining as Food for Humans (1000 tons)	Average Per Capita Share (kg/year)	Surplus or Deficit (1000 tons).
2000	6804	9	6806	7	681	6125	79.5	**-2**
2001	**6338**	1	6334	5	**634**	5700	72.4	4
2002	6789	1	6785	5	679	6106	74.6	4
2003	7157	1	7154	**4**	715	6439	78.6	3
2004	7694	1	7688	7	769	6919	82.8	6
2005	8440	2	8420	22	1010	7410	87.0	20
2006	8666	2	8660	8	1299	7361	**95.1**	6
2007	8719	2	8692	29	1478	7214	91.1	27
2008	9267	9	9217	59	2304	6913	85.4	50
2009	**10334**	20	**10212**	142	**2553**	**7659**	92.7	122
2010	8587	14	8459	142	2115	6344	74.9	128
2011	8124	**49**	8092	81	2023	6069	70.2	32
2012	8639	17	8532	124	2133	6399	72.1	107
2013	8307	9	8100	216	2429	5671	62.3	209
2014	8303	10	8068	245	2422	5646	60.5	231
2015	7760	20	7532	248	2134	5398	56.4	228
2016	7321	22	7071	272	2013	5058	51.6	254
2017	6746	10	6518	238	1855	4663	45.5	230
2018	6796	1	6512	285	1869	4643	44.7	261
2019	6814	20	6540	294	1874	4666	43.9	274
2020	6497	17	6208	306	1689	**4519**	41.8	289
2021	6445	15	**6136**	**324**	1587	4549	**41.5**	**309**
Average	**7752**	**11.5**	**7624**	**139**	**1648**	**5976**	**68.4**	**127**

* **Refers to production in addition to greenhouse production of tomatoes.**

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Food Balance Sheets, various issues.

8/2/2023