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The Impact of Climate Change on the Productivity of Some Crops in Egypt

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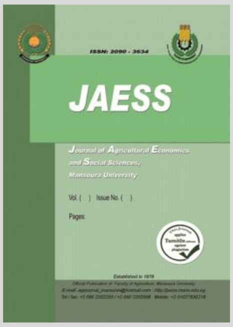

ABSTRACT

The purpose of this study is to determine the impact of climate change(maximum and minimum temperature, relative humidity and precipitation) on the productivity of some crops in Egypt. The results of the multivariate regression model of the impact of climate change on wheat yield from(2005 – 2022)showed that for every unit increase in the average maximum and minimum temperature and precipitation, wheat yield increased by 0.016, 0.036 and 0.066 tons/acre, respectively, which are about 0.59%, 1.32% and 2.42% of the average wheat yield of about 2.73 tons/acre. On the other hand, for every unit increase in the average humidity, the average wheat yield will decrease significantly by about 0.004 tons/acre, which is about 0.15% of the average wheat yield.The increase in average maximum temperature and average humidity led to an increase in rice yield of 0.102 tons/acre and 0.009 tons/acre, respectively, which are 2.87% and 0.25% of the average rice yield of about 3.55 tons/acre. In contrast, the increase in average minimum temperature led to a decrease in average rice productivity of 0.008 tons/acre, which is equivalent to 0.23% of the average rice productivity. The study found that the increase in average minimum temperature led to an increase in potato yield of 0.159 tons/acre, which is equivalent to 1.40% of the average potato yield (about 11.37 tons/acre). For every unit increase in average maximum temperature and average humidity, the average potato yield decreased by 0.051 tons/acre and 0.089 tons/acre, respectively, accounting for 0.45% and 0.78% of the average potato yield, respectively.

***Keywords**:* Climate change, productivity, crops.

INTRODUCTION

Climate change is one of the most important environmental factors affecting human health, including air and water quality. Rising temperatures and changing rainfall patterns are leading to a reduction in global food production of up to 50% (according to the World Health Organization), which could lead to an increase in malnutrition and nutritional deficiencies, resulting in more than 3.1 million deaths each year. The Food and Agriculture Organization also states that the impact of climate change on global food quality poses a threat to food security, in addition to the decline in water quantity and changing rainfall patterns affecting the world's freshwater supply.

Agricultural ecosystems also worsen issues related to greenhouse gases. The agricultural sector is a significant source of greenhouse gas emissions due to nitrous oxide (N_2O) emissions from soil, primarily from the use of nitrogen fertilizers. Methane emissions resulting from internal fermentation and CH_4 the N_2O emissions from natural fertilizer management add to this. These emissions have a significant impact on global food production and contribute to the pollution of drinking water, through nitrates or nitrogen fertilizers. The reliance on chemical fertilizers in agricultural practices is believed to be a major factor in the increase of pollution.

Agricultural ecosystems also exacerbate the problems resulting from greenhouse gases, as sources of greenhouse gas emissions in the agricultural sector include nitrous oxide (N_2O) emissions from soil, especially as a result of the use of nitrogen fertilizers; Methane emissions resulting from internal fermentation, in addition to CH4 and N_2O emissions resulting from the management of natural fertilizers. These emissions greatly affect the world's food production, and also contribute to the contamination of drinking water, whether by nitrates or nitrogen fertilizers. It is believed that agricultural methods that rely on chemical fertilizers are contributing to the increase in pollution.

Research problem and goal:

The problems and challenges are many that face the agricultural sector in Egypt, the effects of which increase over the years as a result of temperature changes, fluctuations in relative humidity and rainfall, in addition to the increasing demand for agricultural products where supply is limited as a result of population growth on which has led to lack of self-sufficiency and decline in the contribution of the agricultural sector to GDP to the lowest levels resulting in deterioration in productivity of some field crops in Egyptian governorates. The research aims at studying climate change (maximum and minimum temperatures, relative humidity, rainfall) impact on productivity for some cereal crops in Egypt.

Research method and data sources:

The research relied on both descriptive and quantitative analysis methods to describe and analyze the topics it covered, using a variety of statistical tools such as estimation by arithmetic mean and multiple regression analysis. Its data sources were based on secondary information published from various sources within the Economic Affairs Sector, Central Administration for Agricultural Economics - Ministry of Agriculture and Land Reclamation, and Central Agency for Public Mobilization and Statistics.

RESULTS AND DISCUSSION

First: wheat crop:

Development of wheat crop productivity:

A- Development of wheat productivity in new and old lands:

B- The indicators listed in Table (1) show that the wheat productivity of all new and old la ds in the Republic

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during the study period (2008 2022) ranged from a minimum of about 2.73 tons/acre in 2008 to a maximum of about 2, 88 to 2021, with an average annual yield of about 2.74 tons/acre. By examining the overall time trend equation of the development of wheat productivity in new and old areas at the Republic level, Table (2 gives the statistical estimation results for the period (2008 -2022).

C- This clearly shows that none of the traditional statistical forms (linear - inverse - quadratic cubic) have proven their validity. This means that the productivity data for the study period revolve around their arithmetic mean of about 2.74 tons/acre

B- Development of wheat productivity on old lands at the republic level:

The indicators in Table (1) show that the wheat yield on old lands nationwide during the study period (2008-2022). ranged from a minimum of about 2.81 tons/acre in 2008 to a maximum of about 2.94 tons/acre in 2017, with an annual average of about 2.80 tons/acre during the study period. By examining the overall time trend equation of the development of wheat productivity in old countries at the republic level, Table (2) gives the statistical estimation results for the period (2008-2022). None of the common statistical forms (linear - inverse - quadratic - cubic - exponential - growth) were found to be significant.

This means that the arithmetic mean of the productivity data is about 2.80 tons/acre.

Table 1. Development of wheat crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the period (2008-2022).

Years	Total old and new lands	ancient lands	New lands
2008	2.73	2.81	2.35
2009	2.71	2.78	2.34
2010	2.39	2.46	2.04
2011	2.75	2.82	2.43
2012	2.75	2.82	2.43
2013	2.78	2.87	2.43
2014	2.74	2.78	2.54
2015	2.77	2.86	2.41
2016	2.79	2.85	2.53
2017	2.88	2.94	2.63
2018	2.65	2.69	2.47
2019	2.73	2.78	2.54
2020	2.68	2.71	2.51
2021	2.88	2.93	2.60
2022	2.82	2.88	2.63
Average	2.74	2.80	2.46
minimum	2.39	2.46	2.04
the highest rate	2.88	2.94	2.63

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

C- Development of wheat productivity in new lands across the Republic:

An examination of the indicators in Table (2-7) shows the lowest wheat yield in the new production areas of the country during the study period (2008-2022). was about 2.35 tons/acre in 2008, and the highest was about 2.35 tons/acre. In 2022, it was 2.63 tons/acre, and the annual average during the study period was about 2.46 tons/acre. By examining the overall time trend equation of the development of wheat productivity in new production areas at the republic level, Table (2-8) is the statistical estimation result for the period)2008-2022(. is It can be seen that the total wheat production of newly cultivated land in the country generally increased at an annual rate with a significance level of 0.01, reaching about 0.024 tons/acre, which is about 1.0% of the average of about 2.46 tons/acre. The coefficient of determination (R2) is about 0.55, which means that 55% of the change in wheat productivity in the new country in the country is due to factors that reflect the effect of the time component. The significance of the model used in the measurement has been proven in general, using the calculated (F) value.

Table 2. Time trend equations for the evolution of wheat crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the period (2008-2022).

M	Dependent variable	Estimated model	R^2	F	% of annual change
1	Total old and new lands	None of the common statistical forms were significant (Linear - Inverse - Quadratic - Cubic - Exponential - Growth).			
2	ancient lands				
3	New lands	$\hat{Y}_i = 2.26 + 0.024 X_i$)**3.96 (**)40.2(	0.55	15.65	1.00

where:

$\hat{Y}_i$:The estimated value of the dependent variable.

Xi: time variable where i = (1, 2, 3, ..., 15). The value in parentheses indicates the calculated (T) value, (R2) the coefficient of determination, (F) the significance of the model as a whole.

(**) indicates the significance of the regression coefficient at the significance level of 0.01.

Source: Calculated from data in Table (2-5) of the study.

The impact of climate change on wheat crop productivity:

A - The impact of climate change on wheat crop productivity in old and new lands:

After numerous attempts to determine the most important climatic factors that affect wheat crop productivity in old and new lands, multiple regression models indicate that the impact of climate change on wheat productivity during the period from (2008 – 2022), such that a one-unit increase in both the average minimum temperature and average rainfall will increase productivity by 0.093 tons/acre and 0.10 tons/acre. Which is equivalent to about 3.89% and 4.18% of wheat productivity in the old and new lands, respectively, and about 2.39 tons/acre of wheat productivity during the study period. Taking into account the degrees of freedom, 48% of the change in the average wheat productivity in the old and new lands is due to changes in the average minimum temperature, average precipitation, and average humidity. At the same time, the average humidity reached

$$\hat{Y}_i = 1.455 + 0.093 X_{i2} - 0.018 X_{i3} + 0.10 X_{i4}$$

$$(1.72) \quad (2.68)^{**} \quad (-2.12)^{*} \quad (3.09)^{**}$$

$$R2 = 0.59 \quad = 0.48 \qquad F = 5.29$$

where:

$\hat{Y}$i: Average wheat crop productivity with total tons/acre of old and new lands.

Xi2: average minimum temperature in degrees Celsius.

Xi3: Average humidity (%).

Xi4: Average rainfall (mm).

Source: Results of statistical analysis using SPSS for data from my tables (1) in the search, (1) in the appendices.

B - The impact of climate change on wheat crop productivity on old lands:

After conducting several attempts to identify the most important climatic factors affecting wheat productivity in old lands, it is evident from the multiple regression model that analyzes the impact of climate change on wheat productivity in these areas during the period from (2008 – 2022). that an increase of one unit in both the average minimum temperature and average rainfall leads to an increase in wheat productivity by 0.063 tons per acre and 0.060 tons per acre, respectively. This represents approximately 2.43% and 2.32% of the average wheat productivity in old lands, which was about 2.59 tons per feddan during the study period. The adjusted coefficient of determination was 0.17, indicating that 17% of the changes occurring in the average wheat productivity in old lands are attributed to changes in both the average minimum temperature and average rainfall, taking into account the degrees of freedom.

$$\hat{Y}_i = 1.47 + 0.063\, X_{i2} + 0.060\, X_{i4}$$
$$(2.31)^* \quad (1.91)^* \quad (2.03)^*$$
$$R2 = 0.28 = 0.17 \quad F = 2.38$$

where:

Ŷi: Average wheat crop productivity in old lands, tons/acre.

Xi2: average minimum temperature in degrees Celsius.

Xi4: Average rainfall (mm).

Source: Results of statistical analysis using SPSS for data from my tables (1) in the search, (1) in the

C - The impact of climate change on wheat crop productivity in the new lands:

After conducting several attempts to identify the most important climatic factors affecting wheat productivity in new lands, it is evident from the multiple regression model that studies the impact of climate change on wheat productivity during the period from (2008-2022), that with an increase of one unit in both the average minimum temperature and average rainfall, wheat productivity increases by 0.054 tons per feddan and 0.059 tons per feddan, respectively. This represents approximately 2.20% and 2.40% of the average wheat productivity in the new lands, which was about 2.46 tons per feddan during the study period. The adjusted coefficient of determination was 0.12, indicating that 12% of the changes occurring in the average wheat productivity in new lands are attributed to changes in both the average minimum temperature and average rainfall, taking into account the degrees of freedom.

$$\hat{Y}_i = 1.68 + 0.054\, X_{i2} + 0.059\, X_{i4}$$
$$(2.53)^* \quad (1.57) \quad (1.89)^*$$
$$R2 = 0.24 \ = 0.12 \quad F = 1.91$$

where:

Ŷi: Average maize yield tons/acre.

Xi2: average minimum temperature in degrees Celsius.

Xi4 Average rainfall (mm).

Source: Results of statistical analysis using SPSS for data from my tables (1) in the search, (1) in the appendices.

Second: Yellow corn crop:

Development of yellow maize crop productivity:

A- Development of white corn productivity in new and old lands across the Republic:

The indicators shown in Table (3) indicate that the productivity of white maize in both new and old lands across the country during the study period (2008-2022) . ranged from a minimum of approximately 3.17 tons per feddan in 2010 to a maximum of about 3.42 tons per feddan in 2008, with an annual average of around 3.30 tons per feddan during the study period. By studying the general time trend equation for the development of sorghum productivity in both new and old lands at the national level, Table (4) presents the results of the statistical estimation during the period (2008-2022). It is evident that the overall productivity of white maize in both new and old lands across the country has followed a general trend of decline at a statistically significant annual rate at the 0.05 significance level, with a decrease of approximately 0.008 tons per feddan, which represents about 0.25% of the average of approximately 3.30 tons per feddan. Additionally, the coefficient of determination (R^2) reached about 0.20, indicating that 20% of the variations in white maize productivity in both new and old lands nationwide are attributed to factors reflecting the impact of time. The significance of the model used for measurement has been generally demonstrated through the use of the calculated value (F).

Table 3. Development of yellow maize crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the period (2008-2022).

Years	Total old and new lands	ancient lands	New lands
2008	3.15	3.18	2.99
2009	3.21	3.31	2.92
2010	2.96	2.95	3.01
2011	3.11	3.12	3.05
2012	3.11	3.12	3.05
2013	3.17	3.19	3.06
2014	3.29	3.30	3.18
2015	2.98	3.02	2.82
2016	3.19	3.23	3.06
2017	3.35	3.39	3.22
2018	3.17	3.20	2.98
2019	3.25	3.25	3.26
2020	3.33	3.32	3.15
2021	3.31	3.35	3.14
2022	3.16	3.20	3.05
Average	3.18	3.21	3.06
minimum	2.96	2.95	2.82
the highest rate	3.35	3.39	3.26

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

B- Development of white corn productivity in old lands across the Republic:

The study of the indicators in Table (3) indicates that the productivity of white maize in old lands across the country during the study period (2008-2022) ranged from a minimum of approximately 3.18 tons per feddan in 2010 to a maximum of about 3.44 tons per feddan in 2009, with an average annual rate of approximately 3.32 tons per feddan during the study period. By examining the general time trend equation for the development of white maize productivity in old lands at the national level, Table (4) presents the results of the statistical estimation during the period (2008-2022).

Table 4. Time trend equations for the development of yellow maize crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the peril (2008-2022).

M	Dependent variable	Estimated model	R^2	F	% of annual change
1	Total old and new lands	$\hat{Y}_i = 3.4 – 0.008\, X_i$ *)-1.80)** (79.97(	0.20	3.25	-0.25
2	ancient lands	$\hat{Y}_i = 3.4 – 0.009\, X_i$ *)-1.92)** (77.2(	0.22	3.67	-0.28
3	New lands	None of the common statistical forms were significant (Linear - Inverse - Quadratic - Cubic - Exponential - Growth).			

Where:

Ŷi: the estimated value of the dependent variable.

Xi: time variable where i = (1, 2, 3, ..., 15). The value in parentheses indicates the calculated (T) value, (R2) the coefficient of determination, (F) the significance of the model as a whole.

(**): indicates the significance of the regression coefficient at the significance level of 0.01.

Source: Calculated from data in Table 3 of the study.

It is evident that the total productivity of white maize in the old lands across the republic has taken a general downward trend with a statistically significant annual rate at a significance level of 0.05, amounting to approximately 0.009 tons per feddan, which represents about 28% of the average that reaches approximately 3.32 tons per feddan. The coefficient of determination (R^2) was about 0.22, indicating that 22% of the variations in maize productivity in the old lands nationwide are attributed to factors reflecting the impact of the time element. The significance of the model used in the measurement was generally confirmed using the calculated value (F).

C - Developing white corn productivity in new lands nationwide:

The study of the indicators shown in Table (3) indicates that the productivity of white maize in new lands across the republic during the period from (2008 -2022) . ranged between a minimum of approximately 2.82 tons per feddan in 2018 and a maximum of about 3.29 tons per feddan in 2013, with an annual average estimated at around 3.11 tons per feddan during that period. Through the analysis of the general time trend equation for the development of sorghum productivity in new lands, Table (4) presents the results of the statistical estimation for the period from (2008 – 2022). None of the traditional statistical forms (linear, inverse, quadratic, cubic, exponential) showed significant statistical significance. This indicates that the productivity data is distributed around its arithmetic mean of approximately 3.11 tons per feddan.

The impact of climate change on yellow maize productivity:

A - The impact of climate change on the productivity of the yellow maize crop in old and new lands:

After conducting several attempts to identify the most important climatic factors affecting the productivity of yellow corn in both old and new lands, it is evident from the multiple regression model that the impact of climate change on yellow corn productivity in these lands during the period from (2008 – 2022). significant. An increase of one unit in both the average maximum temperature and average humidity leads to a decrease in corn productivity by 0.056 tons per acre and 0.017 tons per acre, respectively, which represents approximately 1.76% and 0.53% of the average corn productivity. The average yield of yellow corn in both old and new lands was about 3.18 tons per acre during the study period. Additionally, the adjusted coefficient of determination reached 0.27, indicating that 27% of the changes occurring in the average productivity of yellow corn in old and new lands are attributed to changes in both the average maximum temperature and average humidity, taking into account the degrees of freedom.

$$\hat{Y}_i = 5.675 - 0.056\, X_{i1} - 0.017\, X_{i3}$$
$$(5.55)^{**} \quad (1.98)^{*} \quad (-2.45)^{*}$$
$$R2 = 0.37 \quad = 0.27 \quad F = 3.56$$

where:

Ŷi: Average productivity of the yellow maize crop on the total of old and new lands, tons/acre.

Xi1: average bone temperature in degrees Celsius.

Xi3: average humidity %.

Source: Results of statistical analysis using SPSS for tabular data (3) in the search, (1) in the appendices.

B- The impact of climate change on the productivity of the yellow maize crop in old lands:

\After conducting many attempts to determine the most important climatic factors affecting yellow maize crop productivity in old lands, it is clear from the multiple regression model that studies the impact of climate change on yellow maize productivity in the period from (2008 -2022). The increase in both average minimum temperatures and average humidity by one unit it increases yellow corn productivity by 0.045 tons/acre and 0.010 tons/acre, respectively. Which represents about 1.40% and 0.31% of the average yellow maize productivity in the old lands, which amounted to about 3.21 tons/acre during the study period. While increasing the average maximum temperature by one unit leads to a statistically significant decrease in yellow maize productivity in old lands by 0.082 tons/acre, which represents about 2.55% of the average yellow maize productivity in those lands. The adjusted coefficient of determination was 0.43, which means that 43% of the changes occurring in the average productivity of yellow maize in the old lands are due to changes in the average minimum temperatures, average maximum temperatures, and average humidity, taking into account the degrees of freedom.

$$\hat{Y}_i = 5.365 - 0.082\, X_{i1} + 0.045\, X_{i2} + 0.010\, X_{i3}$$
$$(4.56)^{**} \quad (-1.91)^{*} \quad (1.05) \quad (-2.21)^{*}$$
$$R2 = 0.48 \quad = 0.43 \qquad F = 4.30$$

where:

Ŷi: Average productivity of the yellow maize crop in the old lands, tons/acre.

Xi1: average bone temperature in degrees Celsius.

Xi2: average minimum temperature in degrees Celsius.

Xi3: average humidity %.

Source: Results of statistical analysis using SPSS for tabular data (3) in the search, (1) in the appendices.

C - Impact of climate change on the productivity of the yellow maize crop in new lands:

After conducting several attempts to identify the most important climatic factors affecting the productivity of yellow corn in new lands, it is evident from the multiple regression model that studies the impact of climate change on yellow corn productivity during the period from (2008 – 2022). that an increase in the average minimum temperature by one unit leads to an increase in yellow corn productivity by 0.052 tons per feddan, which represents approximately 1.70% of the average yellow corn productivity in the new lands, which was about 3.06 tons per feddan during the study period. Meanwhile, an increase in the average maximum temperature and average humidity by one-unit results in a decrease in the average yellow corn productivity in the new lands by 0.099 tons per feddan and 0.021 tons per feddan, respectively, representing approximately 0.29% and 0.67% of the average yellow corn productivity in those lands. The adjusted coefficient of determination was 0.78, indicating that 78% of the changes occurring in the average yellow corn productivity in the new lands are attributed to changes in the average minimum temperatures, average maximum temperatures, and average humidity, taking into account the degrees of freedom.

$$\hat{Y}_i = 6.158 - 0.099\, X_{i1} + 0.052\, X_{i2} - 0.021\, X_{i3}$$
$$(11.1)^{**} \quad (-4.87)^{**} \quad (2.55)^{**} \quad (-5.25)^{**}$$
$$R2 = 0.83 \quad = 0.78 \quad F = 17.79$$

where:

Ŷi: Average productivity of the yellow maize crop in the new lands, tons/acre

Xi1: average bone temperature in degrees Celsius

Xi2: average minimum temperature in degrees Celsius

Xi3: average humidity %

Source: Results of statistical analysis using SPSS for tabular data (3) in the search, (1) in the appendices

Third: Rice crop:

Rice crop productivity development:

A- The development of rice productivity on the total new and old lands in the Republic:

The indicators in Table (5) indicate that rice productivity in both new and old lands in the republic during the study period (2008-2022) . ranged from a minimum of approximately 3.64 tons per feddan in 2018 to a maximum of approximately 4.09 tons per feddan in 2008, with an average annual rate of about 3.90 tons per feddan during the study period.

Through the study of the general time trend equation for the development of rice productivity in both new and old lands at the national level, as shown in Table (6), the results of the statistical estimation during the period from (2008-2022). are presented. It is evident that the total rice productivity in both new and old lands at the national level has shown a general trend towards a significant annual decline. Statistically, this decline was at a significant level of 0.01, amounting to approximately 0.028 tons per feddan, which represents about 0.71% of the average, which was around 2.46 tons per feddan. The coefficient of determination (R^2) was approximately 0.72, indicating that 72% of the changes in rice productivity in both new and old lands nationwide are attributed to factors reflecting the impact of the time element. The significance of the model used for measurement was generally confirmed by the calculated value (F).

Table 5. Development of rice crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the period (2008-2022).

Years	Total old and new lands	ancient lands	New lands
2008	4.09	4.10	3.97
2009	4.03	4.04	3.62
2010	3.96	3.99	3.35
2011	4.02	4.07	3.34
2012	4.02	4.07	3.34
2013	4.03	4.07	3.41
2014	4.00	4.03	3.68
2015	3.96	3.98	3.71
2016	3.92	3.94	3.69
2017	3.79	3.84	3.22
2018	3.64	3.70	3.15
2019	3.68	3.71	3.42
2020	3.74	3.75	3.58
2021	3.84	3.86	3.63
2022	3.74	3.78	3.33
Average	3.90	3.93	3.50
minimum	3.64	3.70	3.15
the highest rate	4.09	4.10	3.97

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

Table 6. Time trend equations for the evolution of rice crop productivity (tons/acre) in old and new lands in the Arab Republic of Egypt during the period (2008-2022).

M	Dependent variable	Estimated model	R^2	F	% of annual change
1	Total old and new lands	$\hat{Y}_i = 4.1 - 0.028 X_i$ **)-5.76)** (94.0(	0.72	33.16	-0.71
2	ancient lands	$\hat{Y}_i = 4.15 - 0.03 X_i$ **)-5.84)** (98.5(	0.72	34.10	-0.69
3	New lands	None of the common statistical forms were significant (Linear - Inverse - Quadratic - Cubic - Exponential - Growth).			

Where:

$\hat{Y}i$: the estimated value of the dependent variable.

Xi: time variable where i = (1, 2, 3, ..., 15). The value in parentheses indicates the calculated (T) value, (R2) the coefficient of determination, (F) the significance of the model as a whole.

(**): indicates the significance of the regression coefficient at the significance level of 0.01.

Source: Calculated from data in Table 5 of the study.

A- development of rice productivity in ancient lands at the republic level:

A study of the indicators presented in Table (2-19) indicates that rice productivity in old lands was at the national level during the study period (2008-2022). It ranged from a minimum of approximately 3.70 tons/feddan in 2018 to a maximum of about 4.10 tons/feddan in 2008, with an annual average of around 3.93 tons/feddan during the study period. By examining the general time trend equation for the development of rice productivity in old lands at the national level, as shown in Table (2-20), the results of the statistical estimation during the period (2008-2022). are evident. It is clear that the total rice productivity in old lands across the country has shown a general downward trend at a statistically significant annual rate at a significance level of 0.01, amounting to approximately 0.03 tons/feddan, which represents about 0.69% of the average of approximately 3.93 tons/feddan. The coefficient of determination (R^2) was about 0.72, indicating that 72% of the changes in rice productivity in old lands at the national level are attributed to factors reflecting the impact of the time element. The significance of the model used in the measurement was generally confirmed using the calculated value.

A- Development of rice productivity on new lands nationwide:

The indicators shown in Table (2-19) indicate that rice productivity in new lands has varied across the republic during the study period (2008-2022), ranging from a minimum of approximately 3.15 tons per feddan in 2018 to a maximum of approximately 3.97 tons per feddan in 2008, with an annual average of about 3.50 tons per feddan during the study period. By studying the general time trend equation for the development of rice productivity in new lands at the national level, Table (2-20) presents the results of the statistical estimation during the period (2008-2022). It is evident that none of the traditional statistical forms (linear, inverse, quadratic, cubic) demonstrated statistical significance, indicating that the productivity data revolves around its arithmetic mean, which is approximately 3.50 tons per feddan.

The impact of climate change on rice crop productivity:

A - The impact of climate change on rice crop productivity in old and new lands:

After conducting several attempts to identify the most important climatic factors affecting rice productivity in both old and new lands, it is evident from the multiple regression model that the impact of climate change on rice productivity during the period from (2008 - 2022) is significant. The analyses indicate that an increase in average humidity by one unit leads to an increase in rice productivity by 0.022 tons per feddan, which represents approximately 0.56% of the average rice productivity in both old and new lands, which was about 3.90 tons per feddan during the study period. In contrast, an increase in average minimum temperature by one-unit results in a decrease in average rice productivity by 0.020 tons per feddan, representing about 0.51% of the average rice productivity in those lands. The adjusted R-squared value was 0.43, indicating that 43% of the changes occurring in average rice productivity in both old and new lands are attributed to changes in both average minimum temperature and average humidity, taking into account the degrees of freedom.

$$\hat{Y}_i = 3.135 - 0.020 X_{i2} + 0.022 X_{i3}$$

$$(2.72)^{**} \quad (-1.62) \quad (2.67)^{**}$$

$$R2 = 0.51 \quad = 0.43 \quad F = 6.27$$

where:

$\hat{Y}i$: Average rice crop productivity with total tons/acre of old and new land.

Xi2: average minimum temperature in degrees Celsius.

Xi3: average humidity %.

Source: Results of statistical analysis using SPSS for tabular data (5) in the search, (1) in the appendices.

B- The impact of climate change on rice crop productivity in ancient lands:

After conducting several attempts to identify the most important climatic factors affecting rice productivity in old lands, it is evident from the multiple regression model that studies the impact of climate change on rice productivity in these lands during the period from (2008 - 2022) that an increase of one unit in both the average minimum temperatures and average humidity leads to a decrease in rice productivity by 0.015 tons per feddan and 0.23 tons per feddan, respectively. This represents approximately 0.38% and 5.85% of the average rice productivity in old lands, which is about 3.93 tons per feddan during the study period. The adjusted coefficient of determination was 0.45, indicating that 45% of the changes occurring in the average rice productivity in old lands are attributed to changes in both the average minimum temperature and average humidity, taking into account the degrees of freedom.

$$\hat{Y}_i = 3.061 - 0.015 X_{i2} - 0.23 X_{i3}$$
$$(3.79)^{**} \quad (-1.5) \quad (-2.86)$$
$$R2 = 0.53 \quad = 0.45 F = 8.78$$

Recommendations

1- It is necessary to adapt to the potential effects of climate change, which leads to a decrease in the average productivity of agricultural crops, by providing varieties that are resistant to heat, humidity, and environmental pressures.

2- Focus must be placed on soil improvement programs and monitoring agricultural practices that are compatible with climate change, through irrigation and fertilization at the appropriate times and with the appropriate amounts of water for each irrigation operation.

3- The study of the impact of climate and environmental changes on the productivity of agricultural crops should be expanded, with a focus on the different varieties of each crop, as the negative effects of climate change on the productivity of the most important agricultural crops have been proven.

APPENDICES

Evolution of average maximum and minimum temperatures, humidity, and precipitation in Egypt during the period (2008-2022).

(Temperature: °C, Humidity: %, Rainfall: mm)

Years	Average bone temperatures	Average minimum temperatures	Average humidity	Average rainfall
2008	3.378	2.747	3.996	1.430
2009	3.346	2.754	4.022	1.433
2010	3.381	2.827	3.916	0.405
2011	3.411	2.885	3.900	0.438
2012	3.411	2.885	3.947	0.770
2013	3.325	2.815	4.015	1.548
2014	3.325	2.815	3.982	1.548
2015	3.421	2.815	3.976	1.409
2016	3.434	2.970	3.920	0.300
2017	3.367	2.821	3.859	1.261
2018	3.408	2.885	3.963	1.047
2019	3.381	2.845	3.742	0.351
2020	3.408	2.912	3.761	1.141
2021	3.411	2.912	3.854	0.963
2022	3.421	2.918	3.861	1.089

Source: Central Agency for Public Mobilization and Statistics, Annual Statistical Book, various issues.

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أثر التغير المناخي علي إنتاجية بعض المحاصيل في مصر

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الملخص

يهدف هذا البحث إلى دراسة تأثير التغير المناخي (مثل درجات الحرارة العظمى، درجات الحرارة الصغرى، الرطوبة النسبية، والأمطار) على إنتاجية بعض المحاصيل الزراعية في مصر. وقد أظهرت نتائج نموذج الانحدار المتعدد أن زيادة كل من متوسط درجات الحرارة العظمى، ومتوسط درجات الحرارة الصغرى، ومتوسط الأمطار بمقدار وحدة واحدة تؤدي إلى زيادة إنتاجية القمح بمقدار 0.016، 0.036، و0.066 طن/فدان على التوالي، مما يمثل حوالي 0.59%، 1.32%، و2.42% من متوسط إنتاجية القمح الذي يبلغ حوالي 2.73 طن/فدان. وعلى الجانب الآخر، فإن زيادة متوسط الرطوبة بمقدار وحدة واحدة تؤدي إلى انخفاض معنوي في متوسط إنتاجية القمح بمقدار حوالي 0.004 طن/فدان، أي ما يعادل 0.15% من متوسط الإنتاج. أما بالنسبة لمحصول الأرز، فإن زيادة كل من متوسط درجات الحرارة العظمى ومتوسط الرطوبة بمقدار وحدة واحدة تؤدي إلى زيادة إنتاجية الأرز بمقدار 0.102 و0.009 طن/فدان، مما يمثل حوالي 2.87% و0.25% من متوسط إنتاجية الأرز البالغ حوالي 3.55 طن/فدان. بينما تؤدي زيادة متوسط درجات الحرارة الصغرى بمقدار وحدة واحدة إلى انخفاض إنتاجية الأرز بمقدار حوالي 0.008 طن/فدان، أي ما يعادل 0.23% من متوسط الإنتاج.وفيما يتعلق بمحصول البطاطس، فإن زيادة متوسط درجات الحرارة الصغرى بمقدار وحدة واحدة تؤدي إلى زيادة إنتاجية البطاطس بمقدار 0.159 طن/فدان، مما يمثل حوالي 1.40% من متوسط إنتاجية البطاطس البالغ حوالي 11.37 طن/فدان خلال فترة الدراسة. بينما تؤدي زيادة كل من متوسط درجات الحرارة العظمى ومتوسط الرطوبة بمقدار وحدة واحدة إلى انخفاض إنتاجية البطاطس بمقدار حوالي 0.051 و0.089 طن/فدان على التوالي، مما يمثل حوالي 0.45% و0.78% من متوسط إنتاجية البطاطس .

الكلمات الداله:التغير المناخي، الإنتاجية، المحاصيل