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An Econometrics analysis for the effect of climate changes on productivity of Clover and Sugar Cane crops in Egypt

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ABSTRACT

The issue of climate change and its impact on the productivity of agricultural crops has become of great importance and requires studying it at the local and global levels. To identify the most important negative or positive results. Egypt is expected to be one of the most countries affected by the impact of climate change; As a result of expected risks on agriculture, agricultural land, water supply and food security. It is also expected that the temperature will rise by about 3.5 degrees Celsius by 2050; Which will have an impact on the feddan productivity of most agricultural crops, as well as a reduced quality and quality of production, also the Egyptian food security. For this reason, the research aimed to study the current situation of each of the cultivated area, productivity and production of the most important crop in the fodder and sugar agricultural group, namely clover and sugar cane . In addition to studying the impact of the dimensions of climate changes represented in (maximum and minimum temperatures, relative humidity and precipitation) on their productivity in the new and old lands in the governorates of Egypt.

It was found that clover cultivations were concentrated in the old lands, despite the superiority of their productivity in the new lands; Where the average productivity during the last 3 years was about 30.90 and 35.07 ton/ feddan, respectively. In addition to the negative impact of climate changes on the productivity of clover in the old lands, it decreased by 0.77 ton/ feddan, while it increased in the new lands by 3.62 ton/ feddan. Which represents about 2.49%, 10.32%, of its average productivity in the old and new lands in the governorates of Egypt during the period (2017: 2019), amounting to about 30.90 and 35.07 ton/ feddan, respectively. The total decrease in the productivity of the sugar cane crop in the old and new lands in the governorates of Egypt was also evident by 3.13%, 1.06%; As a result of the negative impact of climate changes, especially on the level of old land.

Introduction:

Egypt has recently witnessed a significant rise in the prices of white and red meat in general and poultry and its products in particular; this is due to the high prices of feed on which the poultry wealth feeds, which is considered the most important controlling factor in the price of poultry in Egypt by 60%, where the price of a ton of them currently reaches 9.1 thousand pounds. Thus, feed is the main pillar and one of the most important inputs and components of the animal and poultry production sector alike, as it depends on it to provide the needs of individuals of animal protein at an affordable price. The demand for feed is derived from the demand for animal products (meat, dairy, poultry and their derivatives), as the increased demand for these products leads to an increase in the demand for feed. Therefore, the promotion of both livestock and poultry and the development of this entire sector depend to a large extent on the availability of these feeds of various types and the mixing

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rates between them .Green fodder includes many fodder crops, most notably clover crop **(Gerges and Ali, 2021)**. Hence, it is necessary to study the development of the current situation of this harvest, as it is one of the most important crops of green fodder in the winter in Egypt and the world, and a natural source of nitrogen that contributes to the preservation and fertility of the soil, where the cultivated area of it amounted to about 1.63 million fedden in 2019, and its production was estimated at about 53.88 million ton, equivalent to about 87.2% of the production of green fodder of about 61.82 million ton in the same year **(Ministry of Agriculture and Land Reclamation, 2019)**. Therefore, it directly affects the production and prices of animal and poultry products and thus on the importer's quantities of these products to compensate for the shortage of them. The research also aimed to identify the impact of the elements of climate change on its productivity to maintain the quantity produced or to follow certain methods to face these effects and how to deal with them. The sugar cane crop was also chosen to use vegetative growths from it (cane flakes) in feeding animals with clover during harvesting, and it can also be added to available feed sources and a large part of it is used in nutrition and high-quality silage has been manufactured after mixing it with clover for feeding on it in the summer **(Abu Salim, 2010)**. In addition to being considered the most important sugar crop and its voracious needs of water in light of the scarcity and limitations of water resources in Egypt.

Research Problem:

Development processes in Egypt face many challenges that stand in the way of achieving the goal of their creation, and contemporary climate change has become one of the most important obstacles and problems faced by Egypt in general and suffered by the agricultural sector in particular, as it has affected the low productivity, quality and quality of some agricultural crops. Feed and sugar crops are of great importance due to the recent high value of animal and poultry feed in Egypt, which was reflected in the high prices of their products. This necessitates an examination of the current status of the most important crop of green fodder crops and sugary crops. Identify the most important climatic factors affecting these crops to promote them, develop livestock production and provide their products at an affordable price.

Research Objective:

The research aimed to study the evolution of the current status of the production indicators of clover and sugar cane crops, and the extent of the impact of the elements of climate change (maximum and minimum temperatures, relative humidity and rainfall) on their productivity in the governorates of Egypt, whether in the old or new lands; to determine the most important climatic factors affecting the productivity of these two crops and how to benefit from the results we will obtain to mitigate or adapt to the effects resulting from them. These two crops were chosen as the most important green fodder crop in winter, while the sugar cane crop can be used vegetative growths from it (cane flakes) in animal nutrition when mixed with clover or available feed sources, and the manufacture of high-quality silage from them to be fed in the summer, in addition to being considered the most important sugar crop and its voracious water needs in light of the limitations faced by the water resources sector in Egypt.

Research method and sources of data:

The research relied on the tools and methods of descriptive and quantitative analysis; represented by averages and general trend equations, in addition to estimating random models Effect; to identify the most important climatic elements that affect the productivity of the crops under study and interpret their results, which are based on time series data represented in years and cross-sectional data represented by the number of governorates of Egypt and called Panel Data **(Abdel hade and Qadous, 2022)**. This was done through the statistical programs Spss. and the Eviews 10 program, and the research was based on the data of the Bulletin of Agricultural Statistics in the Economic Affairs Sector issued by the Ministry of Agriculture and

Land Reclamation during the time period (2005-2019), the climate bulletins issued by Central Agency for Public Mobilization and Statistics during the time period (2017-2019). This is in addition to the use of research and studies related to the research topic **(CAPMAS, 2017-2019).**

Results and discussion:

First: The current status of the development of productive indicators of clover in the old and new lands in Egypt:

A- The general trend development of the clover area in the old, new lands and at the total level in Egypt during the period (2005: 2020):

By studying the current productive situation for the area of clover in the old, new lands and the total level in Egypt, as shown in the data of table (1); it was found that there was a fluctuation in it from year to year during the study period, where the minimum for them in 2014, 2015 and 2015 by about 1.16, 0.13, and 1.30 million fedden respectively, noting that the area planted in the old lands decreased until it reached its minimum level again by the end of the study period in 2019. The maximum was 1.62, 0.47 and 1.82 million fedden in 2007, 2019 and 2007 respectively. The annual average for them during the same period was about 1.33, 0.21 million fedden respectively during the study period (2005: 2019), and it was clear from the previous presentation that the most important crops of clover crop are located in the old lands by an estimated 86.4% of the average total cultivated area in Egypt during the same period. This illustrates the concentration of clover cultivation in the old lands, which represent almost the total area of permafrost in Egypt, except for

By studying the equations of the general time trend in Table (2) Equation (1) of the area of clover in the old lands during the period (2005: 2019), it was found that the linear model is the best suitable model for the area, and that this area has taken a decreasing general trend of about 0.03 million fedden per year, or equivalent to 2.3% of the average total areas cultivated in old lands in Egypt during the same period, and this decrease was confirmed statistically at a significant level of 1%, and the coefficient of determination reached About 67%; that is, changes that reflect time explain about 67% of the changes in this area during the study period, and the rest estimated at 33% are due to other factors not included in the model.

As shown by equation (4) in table (2) that the cubic model is the best model of the nature of the data of the area of clover in the new lands, where it increased until it reached its maximum limit in 2011 representing about 0.22 million fedden, then decreased until it reached its lowest value by about 0.15 million fedden in 2016, and then began to increase by 0.006 million fedden annually. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 84%.

Equation (7) of the same table showed that the cubic model is also the best model of the nature of the data for the total area of clover, where it increased until it reached its maximum limit in 2007 representing about 1.82 million fedden, then decreased until it reached its lowest value by about 1.30 million fedden in 2015, and then began to increase by 0.006 million fedden annually. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 76%.

B: The general trend development of the productivity of clover in the old and new lands and at the total level in Egypt during the period (2005-2020):

By extrapolating the current situation of clover productivity in the old, new lands and the total level in Egypt in the data of Table (1), it was found that there was a fluctuation in them from year to year during the study period; where the minimum for them in 2009, 2016, 2009 was about 28.86, 28.65, 28.97 ton/ fedden respectively, and the upper limit was about 31.62, 36.39, 32.99 ton/ fedden in 2019 for all of them.

Table1. Development of the productive indicators of clover crop in the lands of Egypt during the period (2005-2019).

Area: (Million Fedden), Yield: (Ton/Fedden), Production: (Million Ton).

	Old lands			New Lands			Total		
Year	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.
2005	1.45	30.16	43.66	0.16	32.51	5.05	1.60	30.39	48.71
2006	1.49	29.67	44.29	0.16	31.92	5.24	1.66	29.89	49.53
2007	1.62	29.15	47.19	0.21	32.72	6.72	1.82	29.55	53.91
2008	1.44	29.65	42.76	0.18	32.64	5.79	1.62	29.98	48.55
2009	1.32	28.86	38.19	0.20	29.71	5.81	1.52	28.97	44.00
2010	1.43	29.18	41.76	0.18	29.58	5.36	1.61	29.23	47.12
2011	1.37	29.13	39.85	0.22	29.42	6.49	1.59	29.17	46.34
2012	1.27	29.10	36.86	0.19	30.34	5.70	1.45	29.26	42.56
2013	1.25	29.38	36.61	0.14	30.44	4.28	1.39	29.49	40.89
2014	1.16	29.23	33.98	0.15	33.13	4.86	1.31	29.67	38.84
2015	1.16	29.93	34.82	0.13	31.63	4.25	1.30	30.10	39.07
2016	1.21	31.48	38.05	0.15	28.65	4.21	1.36	31.17	42.26
2017	1.31	30.23	39.66	0.17	33.68	5.78	1.48	30.63	45.44
2018	1.25	30.87	38.48	0.44	35.13	15.44	1.69	31.98	53.92
2019	1.16	31.62	36.75	0.47	36.39	17.13	1.63	32.99	53.88
Average	1.33	29.84	39.53	0.21	31.86	6.81	1.54	30.16	46.34
Minimum	1.16	28.86	33.98	0.13	28.65	4.21	1.30	28.97	38.84
Maximum	1.62	31.62	47.19	0.47	36.39	17.13	1.82	32.99	53.92

Source: Bulletin of Agricultural Statistics, Part I, Winter Crops, Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, various issues.

Table 2. Results of the equations of the general time trend of the productive indicators of clover crop in the lands of Egypt during the period (2005-2019).

Dependent variable			The model used	R^2	F
Old lands	1	**Area (Million Fed.)**	$\hat{Y}_i = 1.53 - 0.03 X_i$ $(34.5)^{**}$ $(-5.2)^{**}$	0.67	26.9
	2	**Yield (Ton/Fed.)**	$\hat{Y}_i = 30.4 - 0.40 X_i + 0.03 X_i^2$ $(77.7)^{**}$ $(-3.6)^{**}$ $(4.8)^{**}$	0.79	21.9
	3	**Production (Million Ton)**	$\ln\hat{Y}_i = 46.3 - 3.6 \ln X_i$ $(26.6)^{**}$ $(4.2)^{**}$	0.57	17.4
New lands	4	**Area (Million Fed.)**	$\hat{Y}_i = 0.04 + 0.10 X_i - 0.02 X_i^2 + 0.001 X_i^3$ $(3.1)^{**}$ $(-3.9)^{**}$ $(4.6)^{**}$	0.84	18.9
	5	**Yield (Ton/Fed.)**	$\hat{Y}_i = 34.6 - 1.3 X_i + 0.09 X_i^2$ $(26.3)^{**}$ $(-3.4)^{**}$ $(3.9)^{**}$	0.62	9.73
	6	**Production (Million Ton)**	$\hat{Y}_i = 1.24 + 3.5 X_i - 0.64 X_i^2 + 0.03 X_i^3$ $(3.0)^{**}$ $(-3.9)^{**}$ $(4.7)^{**}$	0.87	23.6
Total (old and new lands)	7	**Area (Million Fed.)**	$\hat{Y}_i = 1.53 + 0.12 X_i - 0.03 X_i^2 + 0.001 X_i^3$ $(13.6)^{**}$ $(2.1)^{*}$ $(-3.3)^{**}$ $(3.9)^{**}$	0.76	11.9
	8	**Yield (Ton/Fed.)**	$\hat{Y}_i = 31.02 - 0.6 X_i + 0.05 X_i^2$ $(110.6)^{**}$ $(-7.4)^{**}$ $(9.7)^{**}$	0.93	84.1
	9	**Production (Million Ton)**	$\hat{Y}_i = 46.9 + 3.2 X_i - 0.8 X_i^2 + 0.43 X_i^3$ $(14.3)^{**}$ (1.8) $(-3.3)^{**}$ $(4.2)^{**}$	0.83	17.3

Whereas: Ŷi refers to the estimated value of the dependent variable. Xi: Time variable for the time period (2005:2019) where i = (1, 2, 3... ،15). The value in parentheses indicates the calculated value of (T), (R2) the determination coefficient, (F) the significance of the model, (**) indicates the significance of the regression coefficients at a significant level (0.01), (*) indicates the significance of the regression coefficients at a significant level (0.05).

Source: Calculated from Table 1.

Their average annual average during the same period was 29.84, 31.86 and 30.16 ton/ fedden respectively during the study period (2005: 2019). This requires us to pay attention to the horizontal expansion of clover crop and the addition of new areas through the reclamation and cultivation of land with this crop; as the data indicated that the productivity of clover in new lands exceeds the productivity of old lands, although the cultivation of clover is concentrated in the old lands as explained earlier .

It was clear from the study of the equations of the general time trend in Table (2) of the productivity of the crop of clover in the old and new lands and the total productivity in Egypt during the period (2005: 2019) that the quadratic model is the best statistical model of the nature of data at all levels, where the study of equation (2) of the productivity of the crop in the old lands showed that it decreased until it reached its lowest value in 2009 representing about 28.86 ton/ fedden, and then began to increase by about 0.06 ton/ fedden per year during the period of Study. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 79%, meaning that 79% of the changes in productivity in the old lands are due to time, and 21% are due to other variables that were not included in the equation.

While the productivity of the crop in the new lands decreased until it reached its lowest value in 2016 by about 28.65 ton/ fedden, then began to increase by about 0.18 ton/ fedden per year during the study period. As shown in equation (5). This was confirmed statistically at a significant level of 1%. The determination coefficient was about 62%.

The results of equation (8), which is related to the total productivity of the crop in Egypt, indicated that it decreased until it reached its lowest value in 2009 representing about 28.97 ton/ fedden, and then began to increase by about 0.1 ton/fedden per year during the study period. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 93%.

C- The general trend development of the production of clover in the old, new lands and at the total level in Egypt during the period (2005-2020):

Studying the data of Table (1) it was found that there are discrepancies in the production of clover at the level of old and new lands and the total area by increasing or decreasing during the study period, where the minimum for them in 2014, 2016 and 2014 was about 33.98, 4.21 and 38.84 million ton respectively. The maximum was about 47.19, 17.13 million ton and 53.92 million ton in 2007, 2019 and 2018 respectively. The same table showed that the average total production of clover in each of them amounted to about 39.53, 6.81 and 46.34 million ton respectively during the study period (2005: 2019), and the production of clover crop in old lands represented an estimated 85.3% of the average total production in Egypt during the study period.

From the equation of the general trend No. (3) in table (2), it was found that the double logarithmic model is the best suitable model for the data, as it took a decreasing general trend by an annual statistically significant amount of about 33.98 million ton, with an annual change of about 3.6% of the average clover production of about 39.53 million ton during the study period.

It is also clear from equation No. (6) in the same table that the cubic model is the best model of the nature of the data, where it decreased until it reached its minimum in 2006 by about 119.8 thousand ton, and then increased until it reached its maximum value by about 283.6 thousand ton in 2017, and then began to decrease again by 1.62%, and the determination coefficient reached about 86%.

Similarly, it is clear from equation No. (9) in Table (2) that the cubic model is the best model of the nature of the data, as it decreased until it reached its minimum in 2006 representing about 119.8 thousand ton, and then increased until it reached its maximum value of about 283.6 thousand ton in

2017, and then began to decrease again by 1.62%, and the determination coefficient reached about 86%.

Comparing production at the beginning of the period to its end shows that total production increased by an estimated 5.16 million ton, an estimated increase rate of about 10.6% from 2005, and decreased at the level of old lands by about 4.14 million ton, with a decrease rate estimated at about 9.5% from 2005. While production at the level of the new lands increased by about 12.08 million ton, a decrease rate of about 239.1% from 2005. This underscores the need to expand the cultivation of clover in new lands to outpace the productive efficiency of the old lands.

Second: A Standard Study of the Impact of Climate Change Elements on Clover Productivity in Egypt:

Clover crop is grown throughout the year; accordingly, the climate elements affecting clover crop have been limited to the following equation:

$$\hat{Y}_i = \propto + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \ldots\ldots + \beta_{35} X_{i35} + \beta_{36} X_{i36} + \beta_{37} X_{i37} + \beta_1 D_{i1} + \beta_2 D_{i2} + \beta_3 D_{i3} + \beta_4 D_{i4} + \varepsilon_i$$

Where: $\hat{Y}_i$:Estimated value of clover productivity in Egypt's governorates during the period (2017:2019).

X_{i1} **to** X_{i12}: Maximum temperature throughout the year.

X_{i13} **to** X_{i24}: Minimum temperature throughout the year.

X_{i25} **to** X_{i36}: Relative humidity throughout the year.

X_{i37}**:** Average rainfall rate throughout the year.

D_{i1}**:** Dummy variable that reflects the impact of the productivity of the governorates of the Lower Egypt, and takes 1 and a whistle for the rest of the governorates.

D_{i2}**:** Dummy variable that reflects the productivity effect of Middle Egypt governorates, and takes 1 and zero for the rest of the governorates.

D_{i3}**:** Dummy variable that reflects the impact of the productivity of Upper Egypt's governorates, and takes 1 and zero for the rest of the governorates.

D_{i4}**:** Dummy variable that reflects the productivity effect of governorates outside the valley, and takes 1 and zero for the rest of the governorates.

The result of the multiple linear model ended up with the insignificance of the relationship between each of these variables and the dependent variable due to the existence of econometric problems, especially the problem of linear duplication, which was confirmed by the estimates of the simple correlation coefficients with the correlation coefficients matrix, while it was clear from the stepwise regression model that the most influential factors on the productivity of clover in the governorates of Egypt during the period (2017: 2019) It was as follows:

A- The most important climatic factors affecting the productivity of clover crop in the governorates of Egypt in the old lands:

Clover is grown in 21 governorates at the total level of old lands in Egypt, including 13 governorates in lower Egypt, 4 governorates in Middle Egypt and 5 governorates in Upper Egypt. The standard estimate of the random effect model using the ordinary least squares (OLS) method through Eviews 10 showed that the climatic elements that most affected the productivity of clover crop in Egypt's governorates in the old lands during the study period were; the maximum temperature in April, June and July X_{i4}, X_{i6}, X_{i7}, the minimum temperature in January, September and December X_{i13}, X_{i21}, X_{i24}, relative humidity in March, April, May and August X_{i27}, X_{i28}, X_{i29}, X_{i30}, X_{i32}, average rainfall X_{i37}.

The study of equation (1) showed that the increase in both the maximum temperature in April and July X_{i4}, X_{i7}, the minimum temperature in January and September X_{i13}, X_{i21} and the relative humidity in March, May and August X_{i27}, X_{i29}, X_{i32} one unit each leads to a decrease in the productivity of clover in the governorates of Egypt in the old lands by a statistically significant amount of about 0.29, 0.10, 1.12, 0.89, 0.15, 0.17, 0.31 ton/ fedden respectively, representing about 0.9%, 0.3%, 3.6%, 2.9%, 0.5%, 0.6%, 1.0% of the average productivity of clover at the level of Egypt's governorates in the old lands during the average period (2017: 2019) of about 30.9 ton/ fedden, while increasing both the maximum temperature in June X_{i6}, the minimum temperature in December X_{i24} and the relative humidity in May and August X_{i28}, X_{i30}, and the average rainfall X_{i37} one unit each leads to an increase in the productivity of clover in the governorates of Egypt in the new lands by a statistically significant amount of about 1.97, 0.58, 0.66, 0.35, 0.24 ton/fedden respectively, representing about 6.4%, 1.9%, 2.1%, 1.1%, 0.8% of the average productivity of clover at the level of the governorates of Egypt with new lands during the same period. With regard to the dummy variables D_{i1} and D_{i2}, which reflect the impact of the governorates of Egypt, the statistical morale of them has not been proven; this indicates that there is no fundamental difference in the productivity of clover in the governorates of Egypt in all regions in the new lands.

The value of the modified determination coefficient ($R^{/2}$) was about 56%, which indicates the accuracy of the estimated model, as 65% of the changes in the productivity of clover crop in the governorates of Egypt in the old lands are due to the mentioned factors, while the rest is due to other factors not included in the model. The value of "F" also indicates the significance of the model used at a significant level of 0.01 .

B- The most important climatic factors affecting the productivity of clover crop in the governorates of Egypt in the new lands:

Clover is grown in new lands in 9 governorates in Lower Egypt, 3 governorates in Middle Egypt, 5 governorates in Upper Egypt and 5 governorates outside the valley, a total of 22 governorates at the level of the Republic, and it was found through the standard estimate of the regression model in the random Effect Model using the method of ordinary least squares (OLS) through the Eviews 10 program: that the most climatic factors affecting the productivity of clover crop in the governorates of Egypt in the new lands during the period (2017: 2019) are: maximum temperature in April, May and June X_{i4}, X_{i5}, X_{i6}, minimum temperature in March and December X_{i15}, X_{i24}, relative humidity in May and December X_{i29}, X_{i36} and the dummy variable that reflects both the governorates of Lower Egypt and the governorates of Middle Egypt and the governorates of Upper Egypt (D_{i1}, D_{i2}).

The study of equation (2) showed that the increase of both the maximum temperature in April X_{i4} and the minimum temperature in March X_{i15} one unit each leads to a decrease in the productivity of clover in the governorates of Egypt in the new lands by a statistically significant amount of about 0.87 and 1.79 ton/ fedden respectively, representing about 2.5%, 5.1% of the average productivity of clover at the level of the governorates of Egypt in the new lands of about 35.07 ton/ fedden, while increasing each From the maximum temperature in May and June X_{i5}, X_{i6} and the minimum temperature in December X_{i24} and the relative humidity in May and December X_{i29}, X_{i36} one unit each leads to an increase in the productivity of clover in the governorates of Egypt

$$\hat{Y}_i = 11.9 - 0.29 X_{i4} + 1.97 X_{i6} - 0.10 X_{i7} - 1.12 X_{i13}$$
$$(-2.4)^{**} \quad (7.8)^{**} \quad (-3.9)^{**} \quad (-3.7)^{**}$$
$$- 0.89 X_{i21} + 0.58 X_{i24} - 0.15 X_{i27} + 0.66 X_{i28} - 0.17 X_{i29}$$
$$(-3.2)^{**} \quad (2.9)^{**} \quad (-2.5)^{**} \quad (5.3)^{**} \quad (-2.3)^{**}$$
$$+ 0.35 X_{i30} - 0.31 X_{i32} + 0.24 X_{i37} - 8.86 D_{i1} - 5.58 D_{i3}$$
$$(2.4)^{**} \quad (-4.4)^{**} \quad (3.3)^{**} \quad (-1.6) \quad (-0.1)$$
$$R^2 = 0.66 \quad R^{\backslash 2} = 0.56 \quad F = 6.5^{**} \ldots\ldots\ldots (1)$$

$$\hat{Y}_i = 48.3 - 0.46 X_{i4} + 1.09 X_{i5} + 1.53 X_{i6} - 1.26 X_{i21}$$
$$(-2.5)^{**} \quad (3.3)^{**} \quad (4.2)^{**} \quad (-3.3)^{**}$$
$$- 0.29 X_{i23} + 0.62 X_{i24} + 0.43 X_{i28} - 2.72 D_{i2} - 3.32 D_{i4}$$
$$(-2.0)^{**} \quad (1.8) \quad (3.5)^{**} \quad (-0.6) \quad (-0.8)$$
$$R^2 = 0.41 \quad R^{\backslash 2} = 0.31 \quad F = 4.2^{**} \ldots\ldots (3)$$

$$\hat{Y}_i = 112.9 - 0.87 X_{i4} + 2.61 X_{i5} + 1.02 X_{i6} - 1.79 X_{i15}$$
$$(-3.5)^{**} \quad (5.1)^{**} \quad (2.1)^{**} \quad (-3.7)^{**}$$
$$+ 1.77 X_{i24} + 0.42 X_{i29} + 0.46 X_{i36} - 0.20 D_{i1} - 1.81 D_{i3}$$
$$(3.8)^{**} \quad (3.3)^{**} \quad (2.0)^{**} \quad (-0.1) \quad (-0.4)$$
$$R^2 = 0.41 \quad R^{\backslash 2} = 0.31 \quad F = 4.2^{**} \ldots\ldots (2)$$

in the new lands by a statistically significant amount of about 2.61, 1.02, 1.77, 0.42, 0.46 ton/ fedden respectively representing about 7.4%, 2.9%, 5.0%, 1.2%, 1.3% of the average productivity of clover at the level of The governorates of Egypt are in the new lands. With regard to the dummy variables D_{i1}, D_{i2} which reflect the impact of the governorates of Egypt; the statistical morale of them has not been proven;

this indicates that there is no fundamental difference in the productivity of clover in Egypt's governorates in all regions of the new lands.

The modified determination coefficient shows that 31% of the changes in the productivity of clover crop in the governorates of Egypt in the new lands are due to the aforementioned factors and that the rest are due to other variables not included in the model, and the value of "F" indicates the significance of the model used at a significant level of 0.01.

C- The most important climatic factors that affect the productivity of clover crop in governorates of Egypt:

Clover is grown in Egypt in 13 governorates in Lower Egypt, 4 governorates in Middle Egypt, 5 governorates in Upper Egypt and 5 governorates outside the valley, a total of 27 governorates at the level of the Republic, and it was found through the standard estimate of the regression model in the random Effect Model using the method of ordinary least squares (OLS) through the program Eviews 10: that the most climatic factors affecting the productivity of clover crop in the governorates of Egypt in the total land during the period (2019-2017) is the maximum temperature in April, May and June X_{i4}, X_{i5}, X_{i6}, minimum temperature in September, November and December X_{i24}, X_{i23}, X_{i21}, relative humidity in April X_{i28}. And dummy variable that reflects each of the governorates of Lower Egypt, the governorates of Middle Egypt and the governorates of Upper Egypt.

The study of equation (3) showed that the increase of both the maximum temperature in April X_{i4} and the minimum temperature in September and November X_{i21}, X_{i23} one unit each, leads to a decrease in the productivity of clover in the governorates of Egypt in the total land by a statistically significant amount of about 0.46, 1.26 and 0.29 ton/ fedden respectively, representing about 1.4%, 4.0%, 0.9% respectively of the average productivity of clover in Egypt of about 31.87 ton/ fedden during the average period (2017-2019). while the increase in both the maximum temperature in May and June X_{i5}, X_{i6}, the minimum temperature in December X_{i24}, and the relative humidity in April X_{i28} one unit each leads to an increase in the productivity of clover in the governorates of Egypt by a statistically significant amount of about 1.09, 1.53, 0.62, 0.43 ton/ fedden respectively, representing about 3.4%, 4.8%, 1.9%, 1.3% of the average productivity of clover at the level of the governorates of Egypt The statistical significance of the dummy variables that reflect the impact of clover crop productivity changes in the governorates of Egypt's regions has not been proven.

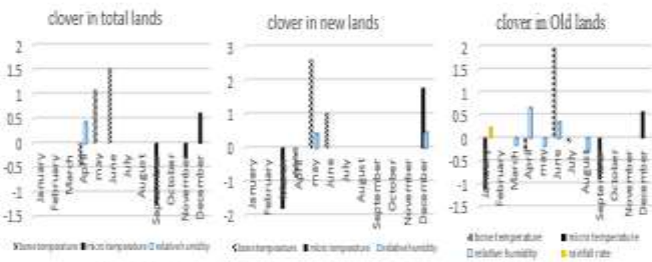
The modified determination coefficient shows that 33% of the changes in the productivity of clover crop in the governorates of Egypt in the total land are due to the aforementioned factors and that the rest are due to other variables not included in the model, and the value of "F" indicates the significance of the model used at a significant level of 0.01.

With regard to the final outcome of the impact of climate change on the productivity of clover crop in Egypt during the period (2017: 2019), it is clear from the previous equations and figure (1):

- The negative impact of climate change on the productivity of clover crop in the old lands, where it was found to decrease by 0.77 ton/ fedden, representing about 2.49% of the average productivity of clover in the old lands in the governorates of Egypt during the study period, which is about 30.9 ton/ fedden.

The positive impact of climate change on the productivity of clover in both the new lands and on the general level in Egypt, where it was shown: Increase the productivity of clover crop in the new lands and in the governorates of Egypt in general by 3.62 and 1.66 ton/ fedden respectively, representing about 10.32%, 5.21% of the average productivity of clover in the new lands and the total governorates of Egypt, which is about 35.07, 31.87 ton/ fedden.

Fig.1. Summary of the results of estimating the random effect model of the impact of climatic factors on the productivity of clover crop in the governorates of Egypt during the period (2017:2019).



Source: Results of statistical analysis with estimated equations during the study period.

Third: The current status of the development of sugar cane production indicators in the old and new lands in Egypt:

A- The general trend development of the sugar cane area in the old, new lands and at the total level in Egypt during the period (2005-2020):

The study of Table (3) showed that there is a fluctuation in the area of sugar cane in excess and decrease in the old, new lands and at the total level in Egypt during the study period; where the minimum for them in the mid-end years of the study period, 2005, 2009:2007 by about 0.28, 0.03, 0.32 million fedden respectively, and the maximum reached about 0.30, 0.05, 0.34 million fedden in 2007, 2019:2017, 2007 respectively. This confirms that the end result is the decrease in the cultivated areas of sugar cane, in line with the limitation of the areas of reeds as a result of its high water needs in light of the scarcity of water resources in Egypt. Their annual average during the same period was about 0.29, 0.04, and 0.33 million fedden respectively during the study period (2005: 2019).

By studying the result of the equations of the general time trend (1 and 7) in Table (4) concerning the area cultivated with the sugar cane crop in the old lands and at the total level in Egypt, it was found that the statistical significance of any of the recognized mathematical models has not been proven, which means that there is a relative stability of the area cultivated by the sugar cane crop in the old lands and at the total level in Egypt. And that the values revolve around the average during the study period

The study of the equations of the general time trend of sugar cane areas in the new lands during the period (2005-2019), in table (4) equation (4) showed that the logarithmic model is the best appropriate model for the nature of the data, as it took an increasing general trend by an annual amount statistically significant with an annual change of about 0.01% of the average area of about 0.04 million fedden during the study period. The determination coefficient was about 48%.

B- The general trend development of sugar cane productivity in the old and new lands and at the total level in Egypt during the period (2005-2020):

By studying the data of Table (3) on the current status of sugar cane productivity in the old and new lands and the total level in Egypt. It turned out that there was fluctuation between them from year to year during the study period; the minimum for them was about 46.83, 44.11, 46.59 ton/ fedden respectively, and the maximum was about 51.51, 47.98, 50.96 ton/ fedden at the beginning of the study period for all of them. Their average annual average during the same period was 49.11, 46.19 and 48.75 ton/ fedden, respectively, during the study period (2005: 2019).

By studying the equations of the general time trend of sugar cane areas during the study period, it was found from Table (4) and equations No. (2, 8) of sugar cane productivity in the old lands and at the total level in Egypt, that the logarithmic model is the best appropriate model for the nature of the data. It took a decreasing general trend with an annual change of about 1.6%, 1.5% respectively during the study period. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 72%, 71% respectively

Table 3. Development of the production indicators of the sugar cane crop in the lands of Egypt during the period (2005-2019) Area: (Million Fedden), Yield: (Ton/ Fedden), Production: (Million Ton).

Year	Old lands			New Lands			Total		
	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.
2005	0.29	51.20	14.66	0.03	47.24	1.65	0.32	50.77	16.32
2006	0.29	51.51	15.03	0.04	46.34	1.63	0.33	50.96	16.66
2007	0.30	51.33	15.19	0.04	46.59	1.82	0.34	50.78	17.01
2008	0.29	51.34	14.66	0.04	47.59	1.81	0.32	50.90	16.47
2009	0.28	49.02	13.72	0.04	47.85	1.76	0.32	48.88	15.48
2010	0.28	48.87	13.82	0.04	47.08	1.80	0.32	48.66	15.62
2011	0.29	48.73	13.93	0.04	46.31	1.84	0.33	48.43	15.77
2012	0.28	48.27	13.71	0.04	44.11	1.84	0.33	47.74	15.55
2013	0.29	48.39	13.80	0.04	45.04	1.98	0.33	47.94	15.78
2014	0.29	48.85	13.99	0.05	45.23	2.07	0.33	48.35	16.06
2015	0.29	48.72	14.18	0.04	46.47	1.72	0.33	48.47	15.90
2016	0.28	47.79	13.47	0.04	44.34	1.95	0.33	47.32	15.42
2017	0.28	47.42	13.28	0.05	45.52	2.10	0.33	47.15	15.38
2018	0.28	48.39	13.56	0.05	47.98	2.26	0.33	48.33	15.82
2019	0.28	46.83	13.23	0.05	45.14	2.10	0.33	46.59	15.34
Average	0.29	49.11	14.02	0.04	46.19	1.89	0.33	48.75	15.91
Minimum	0.28	46.83	13.23	0.03	44.11	1.63	0.32	46.59	15.34
Maximum	0.30	51.51	15.19	0.05	47.98	2.26	0.34	50.96	17.01

Source: Bulletin of Agricultural Statistics, Part II, Summer Crops, Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, various issues.

Table 4. Results of the equations of the general time trend of the production indicators of the sugar cane crop in the lands of Egypt during the period (2005-2019).

Dependent variable			The model used	R^2	F
Old lands	**1**	**Area (Million Fed.)**	The statistical significance of any of the recognized mathematical models has not been proven.		
	2	**Yield (Ton/Fed.)**	$\ln\hat{Y}_i = 52.1 - 1.6 \ln X_i$ $(96.9)^{**}$ $(-6.0)^{**}$	0.72	36.4
	3	**Production (Million Ton)**	$\ln\hat{Y}_i = 15.1 - 0.6 \ln X_i$ $(58.8)^{**}$ $(-4.7)^{**}$	0.61	21.8
New lands	**4**	**Area (Million Fed.)**	$\ln\hat{Y}_i = 0.03 + 0.01 \ln X_i$ $(11.9)^{**}$ $(3.6)^{**}$	0.48	13.0
	5	**Yield (Ton/Fed.)**	The statistical significance of any of the recognized mathematical models has not been proven.		
	6	**Production (Million Ton)**	$\hat{Y}_i = 1.7 + 0.02 X_i$ $(30.8)^{**}$ $(4.4)^{**}$	0.58	19.1
Total (old and new lands)	**7**	**Area (Million Fed.)**	The statistical significance of any of the recognized mathematical models has not been proven.		
	8	**Yield (Ton/Fed.)**	$\ln\hat{Y}_i = 51.6 - 1.5 \ln X_i$ $(99.0)^{**}$ $(-5.9)^{**}$	0.71	35.0
	9	**Production (Million Ton)**	$\ln\hat{Y}_i = 16.7 - 0.4 \ln X_i$ $(66.8)^{**}$ $(-3.5)^{**}$	0.46	11.9

Whereas: $\hat{Y}_i$ refers to the estimated value of the dependent variable. X_i: Time variable for the time period (2005: 2019) where i = (1, 2, 3... ‹15). The value in parentheses indicates the calculated value of (T), (R^2) the coefficient of determination, (F) the significance of the model, (**) indicates the significance of the regression coefficients at a significant level (0.01).

Source: Calculated from Table 3.

By studying the result of the equation of the general time trend no. (5) in Table (4) of the area cultivated with the sugar cane crop in the new lands, it was found that the statistical significance of any of the recognized mathematical models has not been proven, which means that there is a relative stability of the area cultivated with the sugar cane crop in the new lands in Egypt. And that the values revolve around the average during the study period.

C- The general trend development of sugar cane production in the old, new lands and at the total level in Egypt during the period

$$\hat{Y}_i = \propto + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \ldots\ldots + \beta_{35} X_{i35} + \beta_{36} X_{i36} + \beta_{37} X_{i37} + \beta_1 D_{i1} + \beta_2 D_{i2} + \beta_3 D_{i3} + \varepsilon_i$$

(2005-2020):

By studying the current situation of sugar cane production in the old, new lands and the total level in Egypt, as shown in the data of Table (3), it was found that there was a fluctuation in them from year to year during the study period, where the minimum for them in 2019, 2006 and 2019 was about 13.23, 1.63, 15.34 million ton respectively, and the maximum reached about 1.62, 0.47, 1.82 million fedden in 2007, 2019 and 2007 respectively. The annual average of them during the same period was about 1.33, 0.21 and 1.54 million fedden respectively during the study period (2005: 2019), hence the decrease in the production of sugar cane, which requires searching for other sources of sugar production such as the trend towards the production of sugar beet crop instead of sugar cane; to compensate for the noticeable shortage of sugar cane production at the general level so as not to increase the food gap of sugar. Especially since sugar beets are less in water needs than sugar cane.

It also became clear from the study of the equations of the general time trend (3, 9) in table (4) of the production of sugar cane crop in the old lands and the total production in Egypt during the period (2005: 2019) that the logarithmic model is the best statistical model of the nature of the data, as it took a decreasing general trend with an annual change of about 0.6%, 0.4% respectively during the study period. This was confirmed statistically at a significant level of 1%. The determination coefficient was about 61%, 46% respectively.

The study of equation No. (6) in Table (4) showed that the exponential model is the best model of the nature of the sugar cane production data in the new lands, as it took an increasing general trend by an annual percentage statistically significant at a significant level of 1%, with an annual change rate of about 0.02 million ton, during the study period (2005-2019). The determination coefficient was about 58%, meaning that changes that reflect time explain about 58% of the changes in the total production of sugar cane during the study period.

Fourth: A Standard Study of the Impact of Climate Change Elements on Sugar Cane Productivity in Egypt:

The sugar cane crop is grown throughout the year; accordingly, the climate elements affecting on sugar cane crop have been limited to the following equation:

Where: $\hat{Y}_i$: The estimated value of sugar cane productivity in the governorates of Egypt during the period (2017:2019).

X_{i1} **to** X_{i12} : Maximum temperature throughout the year.

X_{i13} **to** X_{i24}: Minimum temperature throughout the year.

X_{i25} **to** X_{i36}: Relative humidity all year round.

X_{i37} : Average rainfall rate throughout the year.

D_{i1}: Dummy variable that reflects the productivity effect of the governorates of the Lower Egypt, and takes 1 and zero for the rest of the governorates.

D_{i2}: Dummy variable that reflects the productivity effect of middle Egypt governorates, and takes 1 and zero for the rest of the governorates.

D_{i3}: Dummy variable that reflects the impact of the productivity of the governorates of Upper Egypt, and takes 1 and zero for the rest of the governorates.

The result of the multiple linear model ended up with the insignificance of the relationship between each of these variables and the dependent variable due to the existence of econometric problems, mainly the problem of linear duplication, which was confirmed by the estimates of the simple correlation coefficients with the correlation coefficients matrix, while it was clear from the stepwise regression model that the most influential factors on sugar cane productivity in the governorates of Egypt during the period (2017: 2019) It was as follows:

A. The most important climatic factors affecting the productivity of the sugar cane crop in the governorates of Egypt in the old lands:

Sugar cane is grown in 15 governorates at the total level of old lands in Egypt, including 6 governorates in Lower Egypt, 4 governorates in Middle Egypt and 5 governorates in Upper Egypt. The standard estimation of the Random Effect Model using the Ordinary Least Squares (OLS) method through Eviews 10 showed that the most climatic elements affecting the productivity of the sugar cane crop in Egypt's governorates in the old lands during the study period were; the maximum temperature in July, September and October X_{i9}, X_{i10} X_{i7}, the minimum temperature in January, February, May, August and October X_{i14}, X_{i17}, X_{i20}, X_{i22} X_{i13}, relative humidity in February, June, July and NovemberX_{i26}, X_{i30}, X_{i31}, X_{i35}.

The study of equation (4) showed that the increase of both the maximum temperature in July and October X_{i7}, X_{i10}, the minimum temperature in May X_{i17}, and the relative humidity in February, June and November X_{i26}, X_{i30}, X_{i35} one unit each leads to a decrease in the productivity of sugar cane in the governorates of Egypt in the old lands by a statistically significant amount of about 1.22, 2.42, 3.42, 0.17, 0.70, 0.50 ton/ fedden respectively, representing about 2.6%, 5.1%, 7.2% , 0.4%, 1.5%, 1.1% of the average sugar cane productivity at the level of Egypt's governorates in the old lands during the average period (2017: 2019) of about 47.54 ton/ fedden, While increasing both the maximum temperature in September X_{i9}, the minimum temperature in January, February, August and October X_{i14}, X_{i20}, X_{i22} X_{i13},, and the relative humidity in July X_{i31} one unit each leads to an increase in sugar cane productivity in the governorates of Egypt in the new lands by a statistically significant amount of about 3.72, 0.50, 0.71, 1.20, 0.03, 0.76 ton/ fedden respectively, representing about 7.8%, 1.1%, 1.5%, 2.5%, 0.1%, 1.6% of the average Sugar cane productivity at the level of Egypt's governorates in the new lands during the same period. With regard to the dummy variables D_{i1} and D_{i3}, which reflect the impact of the governorates of Egypt, the statistical significance of them has been proven; this indicates a fundamental difference in the productivity of sugar cane in the governorates of the lower and upper governorates of Egypt in the old lands.

The value of the modified determination coefficient ($R^{/2}$) was about 74%, which indicates the accuracy of the estimated model, as 74% of the changes in the productivity of the sugar cane crop in the governorates of Egypt in the old lands are due to the mentioned factors, while the rest is due to other factors not included in the model. The value of "F" also indicates the significance of

$$\hat{Y}_i = 90.4 - 1.2\,X_{i7} + 3.72\,X_{i9} - 2.42\,X_{i10} + 0.5\,X_{i13}$$
$$(-5.1)^{**} \quad (13.1)^{**} \quad (-11)^{**} \quad (2.8)^{**}$$
$$+ 0.71\,X_{i14} - 3.42\,X_{i17} + 1.2\,X_{i20} + 0.03\,X_{i22} - 0.17\,X_{i26}$$
$$(3.7)^{**} \quad (-10.8)^{**} \quad (3.7)^{**} \quad (2.8)^{**} \quad (-4.2)^{**}$$
$$- 0.70\,X_{i30} + 0.76\,X_{i31} - 0.50\,X_{i35} - 5.48\,D_{i1} + 3.86\,D_{i3}$$
$$(-8.8)^{**} \quad (7.9)^{**} \quad (-5.7)^{**} \quad (-3.6)^{**} \quad (3.2)^{**}$$
$$R^2 = 0.83 \qquad R^{\backslash 2} = 0.74 \qquad F = 10.2^{**} \ldots\ldots\ldots(4)$$

the model used at a significant level of 0.01.

B-The most important climatic factors affecting the productivity of the sugar cane crop in the governorates of Egypt in the new lands:

Sugar cane is grown on new lands in two governorates in Middle Egypt and 5 governorates in Upper Egypt, a total of 7 governorates at the level of the Republic, and it was found through the standard estimate of the regression model in the random effect model using the method of ordinary least squares (OLS) through the Eviews 10 program: that the most climatic factors affecting the productivity of the sugar cane crop.

in the governorates of Egypt in the new lands during the period (2017): 2019) are: the minimum temperature in April X_{i16}, the relative humidity in May, June, August and December X_{i29}, X_{i30}, X_{i32}, X_{i36} and the dummy variable that reflects the governorates of Upper Egypt (D_{i3}).

The study of equation (5) showed that the increase in the percentage of relative humidity in the months of June and December X_{i30} and X_{i36} one unit each leads to a decrease in the productivity of sugar cane by a statistically significant amount of about 1.13 and 0.37 ton/ fedden respectively, representing about 2.4%, 0.8% of the average productivity of sugar cane at the level of the governorates of Egypt in the new lands of about 46.21 ton/ fedden, while increasing both the minimum temperature in April X_{i16}, and the relative humidity In May and August X_{i29}, X_{i32} one unit each leads to an increase in sugar cane productivity by a statistically significant amount of about 0.38, 0.33, 0.30 ton/ fedden respectively, representing about 0.8%, 0.7%, 0.6% of the average sugar cane productivity at the level of Egypt's governorates in the new lands. With regard to the dummy variables that reflect the impact of the governorates of Egypt, the statistical significance of D_{i3} has been proven; this indicates a fundamental difference in the productivity of sugar cane in the governorates of the Upper Egypt region in the new lands.

The modified determination coefficient shows that 65% of the changes in the productivity of the sugar cane crop in the governorates of Egypt in the new lands are due to the aforementioned factors and that the rest is due to other variables not included in the model, and the value of "F" indicates the significance of the model used at a significant level of 0.01.

$$\hat{Y}_i = 76.4 + \underset{(3.2)^{**}}{0.38 X_{i16}} + \underset{(7.0)^{**}}{0.33 X_{i29}} - \underset{(-11.3)^{**}}{1.13 X_{i30}} + \underset{(4.4)^{**}}{0.30 X_{i32}} - \underset{(-6.6)^{**}}{0.37 X_{i36}} - \underset{(-9.3)^{**}}{8.64 D_{i3}}$$

$$R^2 = 0.76 \qquad R'^2 = 0.65 \qquad F = 7.3^{**} \ldots\ldots (5)$$

C- The most important climatic factors affecting the productivity of the sugar cane crop in governorates of Egypt:

Sugar cane is grown in Egypt in 6 governorates in lower Egypt, 4 governorates in Middle Egypt, 5 governorates in Upper Egypt with a total of 15 governorates at the level of the Republic, and it was found through the standard estimate of the regression model in the random Effect Model using the method of ordinary least squares (OLS) through the program Eviews 10: that the most climatic factors affecting the productivity of the sugar cane crop in the governorates of Egypt in the total land during the period (2019-2017) is the maximum temperature in July, September and October X_{i7}, X_{i9}, X_{i10}, minimum temperature in January, May, June and August X_{i18}, X_{i20}, X_{i17}, X_{i13}, relative humidity in January, May, June, July and November X_{i25}, X_{i29}, X_{i30}, X_{i31}, X_{i35}. The dummy variable that reflects both the governorates of Lower and Upper Egypt (D_{i1}, D_{i3}).

The study of equation (6) showed that the increase of both the maximum temperature in July and October X_{i7}, X_{i10}, the minimum temperature in May and June X_{i17}, X_{i18}, the relative humidity in January, June and November X_{i25}, X_{i30}, X_{i35} one unit each leads to a decrease in the productivity of sugar cane in the governorates of Egypt in the total lands by a statistically significant amount of about 0.72, 2.05, 1.53, 0.85, 0.08, 0.63, 0.38 ton/ fedden respectively, representing about 1.5%, 4.3%. , 3.2%, 1.8%, 0.2%, 1.3%, 0.8% respectively of Egypt's average sugar cane productivity of about 47.35 ton/ fedden during the average period (2017-2019), While increasing both the maximum temperature in September X_{i9}, the minimum temperature in January and August X_{i13}, X_{i20} and the relative humidity in May, July X_{i29}, X_{i31} one unit each leads to an increase in sugar cane productivity in the governorates of Egypt by a statistically significant amount of about 2.94, 0.80, 1.30, 0.16, 0.54 ton/ fedden respectively, representing about 6.2%, 1.7%, 2.7%, 0.3%, 1.1% respectively of the average sugar cane productivity on the level of the governorates of Egypt. With regard to the dummy variables that reflect the impact of the governorates of Egypt, the statistical significance of D_{i1} and D_{i3} has been proven; this indicates a fundamental difference in the productivity of sugar cane in the governorates of Egypt in the lower and upper regions of Egypt. While increasing both the maximum temperature in September X_{i9}, the minimum temperature in January, and August X_{i13}, X_{i20} and the relative humidity in May, July X_{i29}, X_{i31} one unit each leads to an increase in sugar cane productivity in the governorates of Egypt by a statistically significant amount of about 2.94, 0.80, 1.30, 0.16, 0.54 ton/fedden respectively, representing about

$$\hat{Y}_i = 59 - \underset{(-3.5)^{**}}{0.72 X_{i7}} + \underset{(13.1)^{**}}{2.94 X_{i9}} - \underset{(-12.4)^{**}}{2.05 X_{i10}} + \underset{(5.5)^{**}}{0.80 X_{i13}} - \underset{(-8.9)^{**}}{1.53 X_{i17}} - \underset{(-2.8)^{**}}{0.85 X_{i18}} + \underset{(4.6)^{**}}{1.3 X_{i20}} - \underset{(-2.8)^{**}}{0.08 X_{i25}} + \underset{(3.3)^{**}}{0.16 X_{i29}} - \underset{(-9.0)^{**}}{0.63 X_{i30}} + \underset{(7.2)^{**}}{0.54 X_{i31}} - \underset{(-5.1)^{**}}{0.38 X_{i35}} - \underset{(-2.7)^{**}}{3.05 D_{i1}} + \underset{(5.1)^{**}}{4.66 D_{i3}}$$

$$R^2 = 0.81 \qquad R'^2 = 0.72 \qquad F = 9.0^{**} \ldots\ldots (6)$$

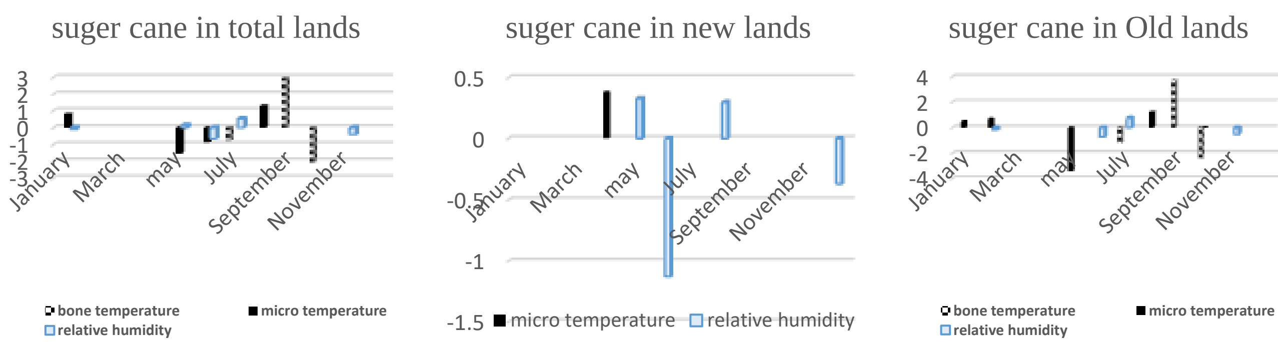
6.2%, 1.7%, 2.7%, 0.3%, 1.1% respectively of the average sugar cane productivity on the level of the governorates of Egypt. With regard to the dummy variables that reflect the impact of the governorates of Egypt, the statistical significance of D_{i1} and D_{i3} has been proven; this indicates a fundamental difference in the productivity of sugar cane in the governorates of Egypt in the lower and upper regions of Egypt.

The modified determination coefficient shows that 72% of the changes in the productivity of the sugar cane crop in the governorates of Egypt in the total land are due to the aforementioned factors and that the rest are due to other variables not included in the model, and the value of "F" indicates the significance of the model used at a significant level of 0.01

With regard to the final outcome of the impact of climate change on the productivity of the sugar cane crop in Egypt during the period (2017:2019), it is clear from the previous equations and figure (2):

The previous equations and Figure (2) showed the negative impact of the final outcome of the impact of climate change on the productivity of the sugar cane crop in both the old and new lands and at the macro level in the governorates of Egypt during the period (2017:2019); where the productivity of the crop decreased by 1.49, 0.49 and 0.50 ton/ fedden respectively. This represents about 3.13%, 1.06%, and 1.06% of the average sugar cane productivity in the old lands, new and total in the governorates of Egypt respectively during the same period, which is about 47.54, 46.21 and 47.35 ton/ fedden respectively.

Fig.2. Summary of the results of the Random Effect Model Estimation of the Impact of Climate Factors on Sugar Cane Crop Productivity in Egypt Governorates during the Period (2017:2019):



Source: Results of statistical analysis with estimated equations during the study period.

Recommendations:

- Focusing on cultivating clover crop in the new lands and expanding it to increase its productivity in it over the old lands, and exploiting the old lands planted with other crops, especially wheat crop.
- Recommends increasing the number of irrigation of clover and irrigation at night, whether in old or new lands; To avoid the negative effect of a minimum temperature rise in the germination stage, which leads to the death of germinated seeds, as shown in the results of the study, where it plants from mid-September until the end of November.
- Reducing the number of mowings of clover to take advantage of the positive effect of the maximum temperature in the months of the growing season because it pushes plants to flowering and increases productivity.
- The need to follow appropriate agricultural operations to avoid the negative impact of relative humidity in March, May and August on productivity in old lands and to prevent the spread of cotton leaf worms from clover to cotton fields.
- Add irrigation water to the appropriate amount, irrigate at night and reduce the use of fertilizers, which in turn raise the soil temperature; To avoid the negative impact of the maximum and minimum temperature rise of sugar cane in the ancient lands, as shown by the research results.
- Preparing an integrated control program for The Pink Borer of Sugar Cane (*Sesamia cretica led*), which infects cane in April and continues to be infected until June; To avoid the negative impact of the maximum and minimum temperature in the old lands in May and the relative humidity in the old and new lands in June.

- Benefiting from the positive impact of the maximum temperature in September in the old lands in combating The European Corn Borer (*Ostrinia nubilalis*) that affects cane starting in August.
- Developing new varieties and strains for the study crops so that their growing season is short to reduce their water needs in light of the scarcity of water resources, and varieties that bear or adapt to the negative effects of climate changes, whether high temperatures or humidity.
- Raising awareness of the use of vegetative growths from sugar cane (Zaazi' al-Qasab) in feeding animals with clover during its harvest, or making silage from them; To contribute to bridging the fodder gap in an unconventional way.

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تحليل اقتصادي قياسي لتأثير التغيرات المناخية على إنتاجية محصولي البرسيم المستديم وقصب السكر في مصر

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الملخص:

باتت قضية التغيرات المناخية وأثرها على إنتاجية الحاصلات الزراعية ذات أهمية بالغة تتطلب دراستها على المستوي المحلي والعالمي؛ للوقوف على أهم النتائج السلبية أو الإيجابية. فمن المتوقع أن تكون مصر احدى الدول الأكثر تضررا من الآثار الناجمة عن تغير المناخ؛ نتيجة للمخاطر المتوقعة على الزراعة، الأراضي الزراعية، إمدادات المياه والأمن الغذائي، كما إنه من المتوقع ان ترتفع درجة الحرارة بنحو 3.5 درجة مئوية بحلول عام 2050؛ مما سيكون له تأثير على الإنتاجية الفدانية لمعظم المحاصيل الزراعية. فضلًا عن انخفاض جودة ونوعية الإنتاج وكذلك الأمن الغذائي المصري. ولهذا استهدف البحث دراسة الوضع الراهن لكل من المساحة المزروعة، الإنتاجية والإنتاج لأهم محصول في المجموعة الزراعية العلفية والسكرية وهما البرسيم المستديم وقصب السكر. بالإضافة إلى دراسة أثر أبعاد التغيرات المناخية والمتمثلة في (درجات الحرارة العظمى والصغرى، الرطوبة النسبية وهطول الأمطار) على إنتاجيتهما بالأراضي الجديدة والقديمة بمحافظات مصر.

وقد تبين تركز زراعات البرسيم المستديم بالأراضي القديمة على الرغم من تفوق إنتاجيته بالأراضي الجديدة؛ حيث بلغ متوسط الإنتاجية خلال أخر 3 سنوات نحو 30.90، 35.07 طن/فدان على الترتيب. بالإضافة إلى التأثير السلبي للتغيرات المناخية على إنتاجية البرسيم بالأراضي القديمة بإنخفاضها بنحو 0.77 طن/فدان، بينما زادت بالأراضي الجديدة بمقدار 3.62 طن/فدان. بما يمثل نحو 2.49%، 10.32%، من متوسط إنتاجيته بالأراضي القديمة والجديدة بمحافظات مصر خلال الفترة (2019:2017) والبالغ نحو 30.90، 35.07 طن/فدان على الترتيب. كما اتضح الانخفاض الكلي في إنتاجية محصول قصب السكر بالأراضي القديمة، الجديدة بمحافظات مصر بنحو 3.13%، 1.06%؛ نتيجة التأثير السلبي للتغيرات المناحية، وخاصة على مستوي الأراضي القديمة.

الكلمات المفتاحية: التغيرات المناخية، محاصيل الأعلاف، المحاصيل السكرية، بيانات السلاسل الزمنية المقطعية.