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Impact of climate change on tomato crop production in some governorates of Egypt

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Abstract: The tomato crop is one of the most affected crops with very cold weather, which leads to moving up their prices, and this can be observed in the high prices of tomatoes in the markets at times which is following periods of the fall of temperature. The area planted with winter tomatoes was estimated about 192.43 thousand feddan, With a feddan productivity of about 17.9 tons and total production was estimated at about 3436.7 thousand tons, with a net return estimated at about 16.73 thousand Egyptian pounds / feddan as an average for the Republic during the period (2000-2021), The problem lies in effect of climate change on both the productivity and quality of the tomato crop, as it is one of the crops whose growth is affected by a temperature drop below 10 degrees Celsius, The research aims to study the effect of climate changes which was represented by the maximum and minimum temperature, humidity and rain on the net return per feddan of the winter tomato crop, Using Ricardo's approach to reach the range of crop sensitivity to climate change , and by applying Ricardo's model to climate change on the net return of feddan for winter tomato crop, it was found that there is an inverse relationship to the effect of the average minimum temperature during the growth period and the square of the average minimum temperature during the cultivation period And also for both the average maximum temperature for the growth period and the harvest period. While it was found that there was a positive effect for both the average minimum temperature and its square for the growth period and the harvest period, as well as the presence of a positive effect for the square of the average maximum temperature for each of the planting period, the growth period and the harvest period. The results of the study indicate the expected scenarios of climate change range on the winter tomato crop that the effect was positive in the case of a decrease in the minimum temperature by about 0.5 to 1 Celsius degree, and the effect was positive in case of a decrease or increase in the quantity of rain by about 5%. **The research recommended the following:** 1- It is preferable to plant winter tomatoes early because they cannot bear the low temperature and are considered warm weather plants, with the selection of the appropriate place and date of planting and the appropriate soil. 2- Developing new varieties that can withstand the change in climatic conditions, as well as expanding the cultivation under the greenhouse to avoid weather fluctuations. 3- Establishing an automated system for early weather warning and forecasting of risks to the tomato crop and other crops, and issuing recommendations to be followed to protect those crops. 4- Establishing an automatic system for early warning of diseases and insects associated with spreading under certain climatic conditions that may infect the tomato crop and other crops and how to avoid or limit them. 5- Training farmers on how to deal with climate changes, how to protect cultivated crops, and Training how to receive text messages and indicative videos through mobile phones from a private local information network maybe without the need for the Internet must be provided. 6- Creating a database for all agricultural crops on which information about those crops is stored and linked to farmers' mobile phones for easy access maybe without the need for the Internet.

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1. Introduction:

The change in the climate is a possible change in the total climate of the surface of the globe as a result of the increase in gas emission and the thermal retention caused by this emission those results in a rise in the temperature of the surface of the globe

The agricultural sector is considered one of the sectors that will be negatively affected by this phenomenon. It is expected that climatic changes will affect the productivity of agricultural land, starting with the influence of the natural, chemical and biological properties of the land and through the spread of pests, insects, diseases and other problems and ending with the effect on the productive crop, Agricultural crops including tomatoes are one of the most prominent things that are affected by the wave of climate changes accompanied by many air phenomena in the winter, such as wind, rain and water jumbling, as well as the fall of colds 'snow' sometimes on some areas, This affects the cultivation of plants, which leads to a slowdown in their growth and productivity and causes economic losses, The tomato crop is most affected by very cold weather, which leads to moving its prices higher and this can be seen in the high prices of tomatoes in the markets at times which witness a marked decrease in Temperature which affects the production of the crop It leads to a shortage of supply in the market,

The area planted with winter tomatoes was estimated at about 192.43 thousand feddans, its productivity was about 17.9 tons / feddan, and its total production was about 3436.7 thousand tons, with a net return of about 16.73 thousand Egyptian Pound / feddan at the level of the Republic during the period (2000-2021), and the research is concerned with the crop Tomato as an important vegetable crop sensitive to climate change.

Research problem:

The world is exposed to current and expected future climatic changes, which may lead to a decrease in the area available for cultivation, and a decrease in the productivity of agricultural crops, including the tomato crop, as it is one of the crops whose growth is affected when the weather temperature drops below 10 degrees Celsius, as well as the frost for plants that did not exceed It is more than 80 days old in open fields, and therefore the total production of this crop decreases. Another problem caused by climatic changes is the low quality of the product, which leads to intolerance to storage and handling, or suffers from poor coloring or maturity, and climate change may lead to such an increase in humidity 80% leads to an increase in the spread of pests and diseases, including bacterial clinics on the tomato crop, which affects the whole agricultural sector. .

Search objectives:

The research aims to study a climate change on the production of the winter tomato crop in Egypt represented by the governorates of Al-Sharqaba, Ismailia, Nubaria and Beni Suef governorates, and to measure the economic impact of the difference in feddan productivity by estimating the index number for the various climate factors, and to identify the productivity of the land in those governorates, and to study Analyzing the variance of the productivity of the tomato crop, and studying the impact of climate change represented in the maximum temperature, minimum temperature, air humidity and the amount of rain on the net return of the winter tomato crop using the Ricardo method, in order to reach the range of crop sensitivity to Climate change .

2. Research method and data sources:

The research used the Ricardo model to assess the economic effects of the climate change on agricultural crops, which is a cross-sectional regression model for the response of the land value or net revenue to changes in environmental characteristics to climate changes. Ricardo's model allows calculating the direct impact of climate on the productivity of different crops, in addition to making indirect substitution between different inputs and the potential transition to a different climate, by directly measuring the prices of agricultural products or revenues, as any element that affects, the productivity of the land is therefore affecting the value of the land Or net revenue, so the value of the land or net revenue contains information about the value of the climate as one of the characteristics of land productivity, and therefore the marginal contributions of all farm income inputs can be determined (Abdul-Gawad sanghi et al., 1998 & 2012).the Ricardo model is based on a set of properties (the two-time differentiation of a continuous function, that the function is almost strongly concave, and that the marginal products are positive). If the production function takes the following form:

$Qi=Qi (Kij,E)$ (1)

Where Qi: the quantity produced for the commodity i, Kij: is the vector of production input j that was used to produce Qi, E: is a vector of external environmental factors such as temperature, rainfall, soil and characteristics of climate locations, given the presence of Wj prices

And each of Q,E and cost minimization for the following cost function:

$Ci=Ci(Qi,W,E)$ (2)

Where: Ci is the cost of producing a commodity i

W (w1,w2……….wn), vector of prices of the elements using the cost function Ci at market prices, and maximizing profits for farmers in a particular location as follows:

$Mx\pi=]PiQi-Ci\ (Qi,W,E)-\ PLLi\ [$ (3)

Where: PL is the annual fixed cost or rent of the land under perfect competition, and the profits that exceed the natural return for all productive elements devolve to zero,

$PiQi-\ Ci=\ (\ Qi,\ W,E)-PL\ Li=0$ (4)

If the production of the E commodity is from the maximum use of the ground, the market rental rent will equate the net annual profits of the production of the commodity. In the case of PL from the previous equation, and that the rent of the land unit is equal to the net revenues for each unit

$PL=\ (Pi\ Qi-\ Ci\ (Qi,\ W,E)/Li$ (5)

Current value of current and future revenue flows gives the land value: V

$$V_L = \int_0^{\infty} P_L e^{-rt} dt = \int_0^{\infty} \left[(P_i Q^*{}_i - C_i(Q^*, W, E) / L_i \right] e^{-rt} dt \quad (6)$$

basis for analysis is the effect of external changes of environmental variables on the net economic luxury, and the net luxury economic is a change in the luxury resulting from the environment change from one region to another, and the change in luxury is measured Economic in terms of change in the capital value of the Earth, or instead in the net lower income. And change in annual luxury as a result of environmental change from an environmental area A to, b, which causes environmental inputs to change from A to E

EB is measured as follows:

$$\Delta W = W(E_B) - W(E_A) = \int_0^{Q_B} \left[(P_i Q_i - C_i(Q_i, W, E_B) / L_i \right] e^{-rt} dQ - \int_0^{Q_A} \left[(P_i Q_i - C_i(Q_i, W, E_A) / L_i \right] e^{-rt} dQ$$

And if the market prices did not change as a result of the change in E, then the previous equation leads to:

$$\Delta W = W(E_B) - W(E_A) = \left[PQ_B - \sum_{i=1}^{n} C_i(Q_i, W, E_B) \right] - \left[PQ_A - \sum_{i=1}^{n} C_i(Q_i, W, E_A) \right] \quad (7)$$

Substitute $P_L L = PiQi^* - Ci\ (Qi^*, W, E)$ from the equation5

$$\Delta W = W(E_B) - W(E_A) = \sum_{i=1}^{n} (P_{LB} L_{Bi} - P_{LA} L_{Ai}) \quad (8)$$

Where: that everyone P_{LA} ‹L_A when E_A *and both* P_{LB} ‹ L_B *when* E_B

The current value of the change of luxury is as follows:

$$\int_0^{Q_B} \Delta W e^{-rt} dt = \sum_{i=1}^{n} (V_{LB} LB_{Bi} - V_{LA} L_{Ai}) \quad (9)$$

The Ricardo model takes either the equation (8) or the equation (9) according to whether the data is available for the net annual returns or the net capital returns (the value of the land VL).

The research relied on some methods of descriptive statistical analysis, such as the percentage and the average, and also the Ricardo curriculum was used, where the net returning of one feddan for the winter tomato crop has been used for each governorate as a dependent variable and it is slope of independent variables, and the non -written model was chosen from the second degree because it is easy to explain [(9)], has been relied on secondary data from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, and the Climate Laboratory, in addition to the use of Some scientific references and studies related to the same research.

Results and Discussion:

The seasonal index of maximum and minimum temperatures and humidity in Sharkia and Ismailia governorates:

Extrapolating the data in Table (1), it was found in Sharkia Governorate that the average maximum temperature during the period (2017-2021) amounted to about 28.72 degrees, and it reached its maximum in July at about 36.06 degrees with an index number of about 125.5%, and it reached the lowest in January at about 19.04 degrees with an index number About 66.3%, and it was found that there was an increase in the maximum temperature during the months (May, June, July, August, September, and October) with an average of about 33.98, 35.04, 36.06, 35.98, 13.9, 30.36 degrees, respectively, with an index number of about 118.34%, 122%, 125.58%, 125.3, 118.06%, 105.7%, respectively It was also found that the average minimum temperature was estimated at 18.49 degrees during that period, and reached a maximum value of about 25.6 degrees in August with an index number estimated at 138.8%, and the lowest value found in January at about 10.6 degrees with an index number of 57.4%, and it was found that there is an increase in The minimum temperature during the months (May, June, July, August, September and October) averaged about 20.7, 23.1, 25.12, 25.68, 23.8, 20.9 degrees, respectively, with an index number estimated at 112.17%, 124.9%, 135.8%, 138.9 %, 128.9%, and 113.47%, respectively, and the average humidity was estimated at about 51.9%, and its maximum value was estimated at about 58.3% in December with an index number of 112.2%, and the lowest value was about 39.2% in May with an index number of 75.4%, in Sharkia Governorate. It was also found that the average maximum **temperature in Ismailia Governorate** was estimated at about 28.8 degrees, and reached its maximum value in August of about 36.1 degrees, with an index number estimated at 125.3%, and its lowest value at about 19.36 degrees in January with an index number estimated at 67.2 %, and it was found that there was an increase in the maximum temperature during the months (May, June, July, August, September, and October) with an average estimated at 33.24, 34.5, 36.08, 36.1, 33.9, 30.8 degrees, respectively, with an index number estimated at 115.3%. , 119.7%, 125%, 125.3%, 117.7%, 107%, respectively, and it was found that the average minimum temperature was estimated at about 16.68 degrees, and reached its maximum value in August of about 23.6 degrees, with an index number estimated at 141.3%, and the lowest value It has an index of about 8.34 degrees in January, with an index of about 50%. 126.5%, 139.8%, 141.7% and 133.48%, respectively, and the average humidity was about 48.46%, and its maximum value was about 54. 9% in December with an index number estimated at 113.2%, and a minimum estimated at 37.48% in May with an index number estimated at 77.3% as shown in Table (1).

The seasonal index of maximum and minimum temperatures and humidity in Nubaria region and Beni Suef governorate:

The data in Table (2) shows the seasonal index for both maximum and minimum temperature and humidity in Beni Suef Governorate during the period (2017-2021).

It was found that the average maximum temperature was estimated at about 29.7 degrees, and its maximum value was about 36.09 degrees, which came in July with an index number of 124%, while its minimum was estimated at about 19.46 degrees, which came in January with an index number estimated at 65.4% , as it turned out that there was an increase in the maximum temperature during the months(April, May, June, July, August, September and October) with an average estimated at 31.48, 35.8, 36.8, 36.9, 36.9, 36.8, 34.9, 31.1 degrees, respectively, with an index number estimated at 105.8%, 120.46, 123.8%, 124, 123.7%, 117.3, and 104.7%, respectively.

Table (1): The seasonal index of maximum and minimum temperatures and humidity in Sharkia and Ismailia governorates during the period (2017-2021)

Months	**Sharkia Governorate**						**Ismailia Governorate**					
	maximum temperature (C°)		**Minimum temperature (c°)**		**Relative humidity %**		**maximum temperature (C°)**		**Minimum temperature (c°)**		**Relative humidity %**	
	Average	**Index number**	**Average**	**Index number**	**Average**	**Index number**	**Average**	**Index number**	**Average**	**Index number**	**Average**	**Index number**
January	19.04	66.31	10.62	57.44	55.66	107.17	19.36	67.18	8.34	50.01	54.48	112.42
February	21.3	74.18	11.78	63.71	56.08	107.97	20.82	72.25	9.84	59.00	52.46	108.25
March	24.38	84.90	14	75.72	49.28	94.88	24.04	83.42	12.28	73.64	46.28	95.50
April	27.9	97.16	16.02	86.64	45.12	86.87	27.58	95.70	14.42	86.47	43.34	89.43
May	33.98	118.34	20.74	112.17	39.18	75.44	33.24	115.34	19.36	116.09	37.48	77.34
June	35.04	122.03	23.1	124.93	45.44	87.49	34.5	119.72	21.10	126.52	42.26	87.21
July	36.06	125.58	25.12	135.86	51.7	99.54	36.08	125.20	23.32	139.84	47.86	98.76
August	35.98	125.30	25.68	138.89	53.76	103.51	36.1	125.27	23.64	141.75	49.04	101.20
September	33.9	118.06	23.84	128.93	55.6	107.05	33.92	117.70	22.26	133.48	50.72	104.66
October	30.36	105.73	20.98	113.47	55.34	106.55	30.84	107.02	18.86	113.09	50.58	104.37
November	25.58	89.08	16.98	91.83	57.82	111.32	27.42	95.15	15.50	92.94	52.12	107.55
December	21.06	73.34	13.02	70.42	58.28	112.21	21.92	76.06	11.20	67.16	54.90	113.29
Average	28.72	100	18.49	100	51.94	100	28.82	100	16.68	100	48.5	100

Source: Ministry of Agriculture and Land Reclamation, Agricultural Research Center, Central Laboratory for Agricultural Climate, unpublished data.

Table (2): The seasonal index of maximum and minimum temperatures and humidity in Beni Suef governorates and the Nubaria region during the period (2017-2021)

Months	Sharkia Governorate						Ismailia Governorate					
	maximum temperature (C°)		Minimum temperature (c°)		Relative humidity %		maximum temperature (C°)		Minimum temperature (c°)		Relative humidity %	
	Average	Index number	Average	Index number	Average	Index number	Average	Index number	Average	Index number	Average	Index number
January	19.46	65.44	6.74	41.12	60.16	122.60	18.24	70.06	9.52	54.69	68	104.95
February	21.64	72.78	8.06	49.17	57.72	117.63	19.7	75.67	10.46	60.09	67.8	104.64
March	24.62	82.80	10.76	65.64	51.32	104.59	21.68	83.27	12.38	71.12	64.2	99.06
April	31.48	105.87	16.64	101.51	37.7	76.83	24.62	94.57	14.48	83.19	61.3	94.49
May	35.82	120.46	20.36	124.21	33.38	68.03	28.84	110.77	18.72	107.55	59.2	91.31
June	36.82	123.83	22.94	139.95	37.84	77.12	30.04	115.38	21.82	125.35	63.9	98.53
July	36.9	124.10	23.76	144.95	43.14	87.92	31.62	121.45	24.6	141.33	66	101.83
August	36.8	123.76	24.04	146.66	44.54	90.77	31.98	122.83	24.8	142.47	66	101.80
September	34.88	117.30	22.44	136.90	46.46	94.68	30.96	118.92	23.64	135.81	63	97.17
October	31.14	104.73	18.72	114.20	51.96	105.89	28.8	110.62	20.02	115.01	62.4	96.31
November	25.98	87.37	13.28	81.02	59.82	121.91	25.08	96.33	15.94	91.57	66.2	102.17
December	21.28	71.57	8.96	54.66	64.78	132.02	20.86	80.12	12.5	71.81	69.8	107.73
Average	29.74	100	16.39	100	49.07	100	26.04	100	17.41	100	64.83	100.00

Source: Ministry of Agriculture and Land Reclamation, Agricultural Research Center, Central Laboratory for Agricultural Climate, former reference.

The average minimum temperature was also estimated at about 16.39 degrees, and its maximum value was about 24.04 degrees which came in August with an index number estimated at 146.6%, and its minimum was estimated at about 6.74 degrees in the month of January with an index number of 41.12%, as it turned out. That there is an increase in the minimum temperature during the months (May, June, July, August, and September) with an average estimate of about 20.36, 22.9, 23.7, 24.04, 22.4 degrees, respectively, with an index number estimated at about 124%. 139.9, 144.9, 146.6%, 136.9%, respectively, and also it was found that the average humidity was about 64.8%, and its maximum value was about

69.8% which came in December with an index number of 107.7%, and a minimum was estimated at about 59.2% which came in May, with an index number of about 91.3% as shown in Table (2).

The data in Table (2) also shows the seasonal index for both maximum and minimum temperature and humidity **in Nubariya** region during the period (2017-2021), and it was found that the average maximum temperature in Nubaria region was about 26.04 degrees, and its maximum value was about 31.9 degrees, which came In August, with a record number of about 122.8%, and its minimum was estimated at about 18.2 degrees, which came in January with an index number of about 70.06%, and it was found that there was an increase in the maximum temperature during the months (May, June, July, August, September, and October) with an average value estimated at 28.8, 30.04, 31.6, 31.5, 30.9, 28.8 degrees, respectively, with an index number estimated at 110.7%, 115.4%, 121.45%, 122.8, 118.9, 110.6%, respectively, and the average minimum temperature was estimated At about 17.4 degrees, and its maximum value was about 24.8 degrees, which came in August, with an index number estimated at 142.47%, and its lowest value was about 9.5 degrees, which came in January with an index number estimated at 54.69%, and it was found that there is an increase in temperature. The smallest during the months (June, July, August, September, and October) with an average of about to

21.8, 24.6, 24.8, 23.6, 20.04 degrees, respectively, with an index number estimated at 125.35%, 141.3%, 142.47%, 135.8%, 115%, respectively, and the average humidity was estimated at 64.8%, and its maximum value with about The index 68.8 % which came in December with an index of 107.7%, and its minimum value was estimated at 59.2% which came in May, with an index of 91.3% as shown in Table (2).

Productive merit of the winter tomato crop in the most important producing governorates in the Republic:

The analysis of variance test depends on the total differences in the average feddan productivity, which may be caused either by differences between governorates and each other or by a factor on the other hand.

In Table (3), the results of the analysis of variance in one direction for the average productivity of the winter tomato crop between the most important producing governorates in the Republic during the period (2016-2021) showed that there were significant differences in the average feddan productivity between governorates, this explains the existence of real differences between the governorates variable on the one hand and the time variable on the other hand.

Table (3): Results of the variance analysis of the average feddan productivity of winter tomato in the most important producing governorates in the Republic during the period (2016-2021)

Source	Type Sum of Squares	DF	Mean Square	F
Between the governorates	642.572	14	45.898	11.89**
Error	289.446	75	3.859	
Total	932.018	89		

Source: Compiled and calculated from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Bulletin, various issues.

In Table (4), the results of estimating the significant differences between the average feddan productivity of winter tomatoes between governorates using the least significant difference (LSD) test showed that Sohag governorate occupies the first place according to the feddan productivity, which was estimated at 23.89 tons / feddan, which differed by a significant difference compared to its counterparts In the rest of the governorates, Sharkia governorate came in second place with an average productivity estimated at 22.94 tons / feddan, which differed with a significant difference compared to its counterparts in the Nubaria region and the governorates of Kafr El-Sheikh, Beheira, Assiut, Suez, Menoufia, and Beni Suef, where they Were the differences were estimated at 7.1, 7.09, 7.02, 7.01, 5.94, 5.05, and 4.8 tons / feddan, respectively. Ismailia Governorate came after them in the third place, with average feddan productivity estimated at 22.71 tons / feddan which differed with a significant difference compared to its counterparts in Nubaria and the governorates of Kafr El-Sheikh, Beheira, Assiut, Suez, Menoufia, and Beni Suef, where the differences were estimated at about 6.87, 6.86, 6.79, 6.78, 5.71, 4.82, 4.58 tons / feddan. In order, Luxor Governorate came after them in the fourth place with a feddan productivity estimated at 20.89 tons / feddan, which differed with a significant difference compared to its counterparts in the Nubaria region and the governorates of Kafr El-Sheikh, Beheira, Assiut, Suez, Menoufia, and Beni Suef, the differences were estimated With about 5.05, 5.04, 4.97, 4.96, 3.89, 3.00, 2.76 tons / feddan, respectively, the governorate of Alexandria came in the fifth place, with feddan productivity estimated at about 20.53 tons / feddan, which differed significantly compared to its counterparts in the Nubaria region and the governorates of each Kafr El Sheikh , Beheira, Assiut, Suez, Menoufia, and Beni Suef, where the differences were estimated at 4.69, 4.68, 4.6, 4.61, 3.5, 2.6, 2.4 tons / feddan, respectively.

After them came Minya governorate in the sixth rank with feddan productivity estimated at 20.35 tons / feddan, which differed with a significant difference compared to its counterparts in the Nubaria region and the governorates of Kafr El-Sheikh, Beheira, Assiut, Suez and Menoufia, where the differences were estimated at about 4.51, 4.5, 4.43, 4.42, 3.35, 2.46 tons/feddan respectively, then Qena governorate in seventh place with feddan productivity estimated at about 19.58 tons/feddan which differed by a significant difference compared to its counterparts in Nubaria and the governorates of Kafr El-Sheikh, Beheira, Assiut, and Suez, where the differences were estimated at 3.74, 3.73, 3.66, 3.65, 2.58 tons / feddan, respectively, then in the eighth place was the Giza governorate with feddan productivity estimated at about 18.85 tons / feddan which was significantly different compared to its counterparts in the Nubaria region and the governorates of each from Kafr El-Sheikh, Beheira, and Assiut, where the differences were estimated at 3.01, 3, 2.93. 2.92 tons / feddan respectively, then Beni Suef governorate came in ninth place with feddan productivity estimated at about 18.18 tons / feddan which differed with a significant difference compared to its counterparts in Nubaria and Kafr El-Sheikh governorate, where the differences were estimated at 2.29, 2.28 tons / feddan respectively, then came the governorates of Menoufia, Suez, Assiut, Beheira, Kafr El-Sheikh, and the Nubaria region with productivity estimated at about 17.89, 17.00, 15.93, 15.92, 15.85, 15.84 tons / feddan, respectively, without significant differences between them. From the above, the main governorates producing the winter tomato crop in the Republic can be classified according to the production merit criterion or the average feddan productivity of the governorates during the period (2016-2021) into three production areas:

Table (4) Results of the least significant difference (LSD) test for the significance of differences between the most important governorates producing winter tomatoes During the period (2016-2021)

governorates	Productivity ton/feddan	Suhag	sharkia	Ismailia	Luxor	Alexandria	Menia	Qena	Giza	Beni Suef	Menoufia	Suez	Assuit	Behera	Kafr-El Sheikh	Noubaria
		23.89	22.94	22.71	20.89	20.53	20.35	19.58	18.85	18.13	17.89	17	15.93	15.92	15.85	15.84
Suhag	23.89	0														
Sharkia	22.94	0.95														
Ismailia	22.71	1.18	0.23													
Luxor	20.89	*3	2.05	1.82												
Alexandria	20.53	*3.36	*2.41	2.18	0.36											
Menia	20.35	*3.54	*2.59	*2.36	0.54	0.18										
Qena	19.58	**4.31	*3.36	*3.13	1.31	0.95	0.77									
Giza	18.85	**5.04	**4.09	*3.86	2.04	1.68	1.5	0.73								
Beni Suef	18.13	**5.76	**4.81	**4.58	*2.76	*2.4	2.22	1.45	0.72							
Menoufia	17.89	**6	**5.05	**4.82	*3	*2.64	*2.46	1.69	0.96	0.24						
Suez	17	**6.89	**5.94	**5.71	*3.89	*3.53	*3.35	*2.58	1.85	1.13	0.89					
Assuit	15.93	**7.97	**7.01	**6.78	**4.96	**4.6	**4.42	*3.65	*2.92	2.2	1.96	1.07				
Behera	15.92	**7.97	**7.02	**6.79	**4.97	**4.61	**4.43	*3.66	*2.93	*2.21	1.97	1.08	0.01			
Kafr-El Sheikh	15.85	**8.04	**7.09	**6.86	**5.04	**4.68	**4.5	*3.73	*3	*2.28	2.04	1.15	0.08	0.07		
Noubaria	15.84	**8.05	**7.1	**6.87	**5.05	**4.69	**4.51	*3.74	*3.01	*2.29	2.05	1.16	0.09	0.08	0.01	0

** Significant at 0.01 * Significant at 0.05 level

Source: Compiled and calculated from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Bulletin, various issues.

The first productive area:

It includes the highest productive feddan governorates, which ranges between a maximum and a minimum of about (23.89 -20.35) tons / feddan. It includes the governorates of Sohag, Sharkia, Ismailia, Luxor, Alexandria, and Minya.

The second production area:

It includes the governorates with median feddan productivity, which ranges between a maximum and a minimum of about (19.58 - 17.00) tons / feddan, including the governorates of Qena, Giza, Beni Suef, Menoufia, and Suez.

The third productive area:

It includes the governorates with low feddan productivity, which ranges between a maximum and a minimum of about (15.93-15.84) tons/feddan. It includes Assiut, Beheira, Kafr El-Sheikh, and the Nubaria region.

From the above, we conclude that there are significant differences in feddan productivity between the governorates producing the winter tomato crop, which can be attributed to climatic changes from one governorate to another.

First: The economic impact of climate change on the winter tomato crop:

The data in Table (5) indicate that the average net return per feddan for the tomato crop amounted to about 21417.3 pounds / feddan, and the maximum reached about 64,470 pounds in 2021 at the level of the four governorates that were selected in the research. And with a statistically significant change of about 3060.6 pounds / feddan, representing about 11.2% of the average net return per feddan during the period (2000-2021), the average minimum temperature was estimated about 20.22, 12.20, and 11.13 degrees for the planting, growth and harvest periods, the statistical significance of both the planting and growth period was not proven. The maximum temperature was about 31.15, 22.83, and 23.09 degrees, respectively, for the periods of planting, growth and harvest, and the statistical significance of any of them was not proven, while the average relative humidity was about 55.34%, 60.86%, 55.94% for the periods of planting, growth and harvesting, with an average Statistically significant change amounted to about 0.79%, 0.34% for both planting and harvesting period, while The statistical significance of the growth period was not proven. It was found that the average amount of rain was estimated at about 2.64, 13.63, 9.02 millimeters for each of the planting, growth and harvest periods, with a statistically significant change rate of about 6.77%, 4.85% for both growth and harvest period, the statistical significance of the planting period was not proven.

It was found from the study of the Ricardo model of the impact of climate changes on the net feddan return of the winter tomato crop during the period (2000-2021) that the variables under study explain about 91% of the changes in the dependent variable, as it shows significant effect of some variables under study except for some others on As follows for each of: the effect of the average minimum temperature for the harvest period, the average maximum temperature for the planting period, the average minimum temperature × average humidity for the harvest period, the average minimum temperature × the average rainfall for the growing period, the average maximum temperature × the average amount of rain for the period Growth, average maximum and minimum temperature x average humidity x average rainfall for both planting and growth period.

It was also shown from Table (6) that there is an inverse relationship for some of the variables under study on the dependent variable as follows: The effect of the average minimum temperature for each of the growth period and its square for the cultivation period, the average maximum temperature for both the growth and harvest period, the average amount of rain for each period Planting, growth and harvest and their square, average relative humidity for growth and its square for the harvest period, average minimum temperature x average relative humidity for the cultivation period, average minimum temperature x average amount of rain for the cultivation period, average maximum temperature x average relative humidity for the sowing and harvest period, and average temperature Maximum × average humidity × average amount of rain for the harvest period on the net return of the tomato crop.

While the positive effect of some variables under study on the dependent variable was shown as follows: the average minimum temperature for planting and its square for the growth period and the harvest period, the square of the average maximum temperature for each of the planting, growth and harvest period, the average humidity for each of the planting and harvesting period and its square for the growth period , square of the average amount of rain for the planting period and average minimum temperature × average humidity for the growing period on the net return of tomatoes.

Table (5) Climate Factors and the net feddan return of the winter tomato crop during the period (2000-2021)

Governorates/years	Average net return (egy.pound/ feddan)	maximum temperature (C°)			Minimum temperature (c°)			Relative humidity %			Rain quantity mm		
		planting	growth	harvest	planting	growth	harvest	planting	growth	harvest	planting	growth	harvest
Ismailia	22943.18	18.34	10.99	10.63	29.51	21.95	22.96	51.53	54.18	54.97	0.36	1.12	3.39
sharkia	20199.87	21.55	13.86	12.71	31.80	23.04	23.23	56.51	59.32	51.87	3.01	12.51	6.09
noubaria	27317.77	20.98	13.71	11.58	29.89	22.50	21.43	63.30	66.45	63.81	7.09	40.06	25.32
Beni suef	15208.53	20.00	10.25	9.61	33.39	23.85	24.73	50.01	63.49	53.10	0.09	1.64	1.29
Average	21417.34	20.22	12.20	11.13	31.15	22.83	23.09	55.34	60.86	55.94	2.64	13.83	9.02
2000	5845.67	19.13	12.80	9.94	30.33	22.38	21.88	61.26	68.47	60.58	6.65	16.84	8.67
2001	-1820.85	19.49	11.03	10.82	31.03	22.56	23.68	59.40	62.24	59.31	0.51	9.53	7.24
2002	4330.33	20.71	12.18	11.08	32.48	23.60	23.13	58.05	60.50	58.91	0.64	10.45	2.52
2003	8436.74	19.74	11.83	10.62	32.15	23.05	23.04	58.78	65.91	53.11	0.00	4.86	14.69
2004	4796.08	19.81	11.74	10.89	32.24	23.55	23.46	59.34	61.08	55.30	0.00	2.06	3.32
2005	6944.91	19.79	11.48	11.01	31.74	22.71	23.53	57.75	63.81	54.72	0.00	0.89	2.59
2006	13521.21	20.05	10.59	10.84	31.64	21.88	23.06	56.95	65.24	60.01	0.51	10.13	9.80
2007	9581.92	20.53	11.79	9.99	31.35	23.66	21.14	60.36	61.58	55.08	0.76	10.41	9.14
2008	10231.07	20.53	13.01	10.83	31.36	24.34	23.26	58.99	61.76	58.47	3.68	2.92	6.92
2009	8256.95	20.96	12.56	11.23	32.28	23.80	23.58	59.61	61.86	53.31	0.26	6.54	4.40
2010	9830.36	21.54	12.96	12.64	32.98	24.90	25.41	56.31	64.49	55.31	0.76	4.03	2.71
2011	28054.60	19.94	10.63	11.30	31.23	21.46	22.89	56.73	66.26	58.76	0.51	16.89	8.46
2012	24606.67	20.41	12.96	10.17	31.80	23.68	21.87	59.13	64.49	55.80	0.25	12.54	10.26
2013	30232.68	15.60	9.53	11.16	23.74	17.28	23.68	41.83	48.38	54.28	0.00	19.72	8.80
2014	28154.29	18.76	11.44	11.39	28.85	21.38	23.55	40.80	47.55	57.84	2.16	9.67	8.47
2015	37611.24	19.53	11.90	10.62	29.22	21.01	22.40	45.38	54.01	54.57	18.45	30.54	5.15
2016	33159.43	21.55	12.96	12.20	31.69	22.90	24.01	54.23	58.88	53.07	9.02	36.09	6.48
2017	29113.68	20.58	13.38	11.10	31.23	24.04	22.18	51.41	60.75	53.71	10.00	10.51	6.72
2018	35978.10	21.70	13.25	12.97	31.83	23.15	24.68	54.38	61.58	53.44	0.92	21.97	23.86
2019	31027.00	21.45	13.61	10.54	31.75	24.29	21.83	55.90	58.28	52.99	0.67	13.72	11.81
2020	48818.92	22.19	13.35	11.48	33.28	23.35	21.98	56.33	61.00	56.32	0.89	22.54	20.19
2021	64470.42	20.81	13.53	12.14	31.18	23.41	23.68	54.55	60.78	55.71	1.40	31.46	16.31
Average	21417.34	20.22	12.20	11.13	31.15	22.83	23.09	55.34	60.86	55.94	2.64	13.83	9.02
change rate%	11.02**	0.32	0.62	0.53*	0.09	0.01	0.005	0.79*	0.56	0.34*	6.27	6.77*	4.85*

Significant at the 0.01% level * Significant at 0.05% * Rate of change = b / arithmetic mean x 100

The winter planting period for tomatoes is in the months of September and October, the growth period is from November to February, the harvest period is during the period from January to April.

Source: (1) Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Bulletin, various issues.

(2) Ministry of Agriculture and Land Reclamation, Central Laboratory of Agricultural Climate, unpublished data.

Table (6) estimation of the Ricardo model for the impact of climate change on the net feddan return of the winter tomato crop during the period (2000-2021)

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Average Minimum temperature for the Planting period	75897.84	4129.35	18.38	0
Average Minimum temperature for the growth period	-36989.04	2460.74	-15.03	0
Average Minimum temperature for the harvest period	-2340.568	1815.41	-1.28	0.1974
Average Minimum temperature Square for the Planting period	-1504.514	84.06	-17.89	0
Average Minimum temperature Square for the growth period	1391.596	55.26	25.18	0
Average Minimum temperature Square for the harvest period	123.9351	50.29	2.464	0.01
Average maximum temperature for the Planting period	6369.09	4075.128	1.56	0.11
Average maximum temperature for the growth period	-57926.16	4178.12	-13.86	0
Average maximum temperature for the harvest period	-12806.07	1115.07	-11.48	0
Average maximum temperature Square for the Planting period	114.24	48.66	2.34	0.01
Average maximum temperature Square for the growth period	652.23	72.22	9.03	0
Average maximum temperature Square for the harvest period	272.20	25.43	10.70	0
Average relative humidity for the Planting period	21821.74	1011.68	21.56	0
Average relative humidity for the growth period	-18698.41	807.28	-23.162	0
Average relative humidity for the harvest period	6110.61	310.16	19.701	0
Average relative humidity Square for the Planting period	-78.83	4.15	-18.97	0
Average relative humidity Square for the growth period	64.39	4.24	15.18	0
Average relative humidity Square for the harvest period	-34.54	3.176	-10.87	0
Average quantity of rain for the Planting period	-3813.32	1208.45	-3.15	0.001
Average quantity of rain for the growth period	-2377.63	178.57	-13.31	0
Average quantity of rain for the harvest period	-6346.21	278.05	-22.82	0
Average rain Square for the Planting period	25.05	1.817	13.78	0
Average rain Square for the growth period	-5.781	0.351	-16.46	0
Average rain Square for the harvest period	-9.15	0.712	-12.84	0
Average Minimum temperature x average relative humidity for the Planting period	-406.62	27.45	-14.80	0
Average Minimum temperature x average relative humidity for the growth period	116.10	25.43	4.56	0
Average Minimum temperature x average relative humidity for the harvest period	-20.78	26.94	-0.77	0.44
Average Minimum temperature x average quantity of rain for the Planting period	-1844.49	744.14	-2.47	0.01
Average Minimum temperature x average quantity of rain for the growth period	-29.12	104.43	-0.27	0.78
Average Minimum temperature x average quantity of rain for the harvest period	-742.35	111.58	-6.65	0
Average maximum temperature x average relative humidity for the Planting period	-149.02	23.80	-6.26	0
Average maximum temperature x average relative humidity for the growth period	389.805	22.91	17.007	0
Average maximum temperature x average relative humidity for the harvest period	-40.98	13.66	-2.99	0.002
Average maximum temperature x average quantity of rain for the Planting period	1491.89	525.53	2.83	0.004
Average maximum temperature x average quantity of rain for the growth period	108.41	63.39	1.71	0.08
Average maximum temperature x average relative humidity for the growth period	389.805	22.91	17.007	0
Average maximum temperature x average quantity of rain for the harvest period	692.07	61.73	11.21	0
Average Minimum temperature x average humidity x average quantity of rain for the Planting period	14.54	12.94	1.123	0.26
Average Minimum temperature x average humidity x average quantity of rain for the growth period	0.291	1.555	0.18	0.85
Average Minimum temperature x average humidity x average quantity of rain for the harvest period	19.85	1.847	10.74	0
Average maximum temperature x average humidity x average quantity of rain for the Planting period	-12.12	9.084	-1.33473	0.18
Average maximum temperature x average humidity x average quantity of rain for the growth period	0.291	0.975	0.29	0.76
Average maximum temperature x average humidity x average quantity of rain for the harvest period	-10.422	1.082	-9.62	0
Location	-1665.55	158.51	-10.50	0
Time	2523.66	24.77	101.85	0
	R-squared	0.907	Mean dependent var	17291.11
	Adjusted R-squared	0.906	S.D. dependent var	14910.58
	S.E. of regression	4560.32	Akaike info criterion	19.69
	Sum squared resid	8.14E+10	Schwarz criterion	19.76
	Log likelihood	-38960.46	Hannan-Quinn criter.	19.72
	Durbin-Watson stat	1.51		

Source: (1) Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Bulletin, various issues.

Second: Simulating the impact of climate change on the winter tomato crop

To simulate the impact of climate change [10] The parameters that was estimated using the model shown in Table (6) has been used for the purpose of measuring the effect of the change in each of the temperature, relative humidity and the amount of rainfall on the net return per feddan of the winter tomato, and the expected effect has been predicted for several scenarios includes moving the minimum and maximum temperature by about 0.5:1 degrees Celsius, the relative humidity by about 10%, and the amount of rainfall by about 5% by an increase and decrease, taking into account that the level of climate change is associated with the doubling of carbon dioxide [8].

Figure (1) shows that the minimum temperature ranged between a minimum and a maximum of 14-23.3 degrees and had a positive effect on the net return per feddan of tomato crop when it was increased to a higher degree than the critical degree, which is about 10.5 degrees, while it ranged The maximum temperature range is between a minimum and a maximum of 14.9-34.7 degrees Celsius, the maximum temperature has a negative effect on the net return per feddan of the winter tomato crop when moved in both directions, down and up, This occurs only outside the critical range of the maximum temperature suitable for production, which ranged between both minimum and maximum limits, which amounted to about 14.9-29.8 degrees Celsius, while the maximum relative humidity ranged between minimum and maximum limits of 40.6%: 71.1% , It has been found that the higher the maximum relative humidity leads to an increase in the net return per feddan, and the higher the minimum relative humidity, the lower the net return. and it turns out that the quantity of rain ranges between 17.2-85.8 millimeters. Rain leads to an increase in the net yield of the tomato crop.

Table (7) shows the prediction scenarios of the impact of climate changes on the winter tomato crop:

The first scenario:

The estimated average net return per feddan when the minimum temperature drops by 0.5°C.

The second scenario:

Rhe estimated average net return per feddan when the minimum temperature drops by one Celsius degree.

The third scenario:

The estimated average net return per feddan when the maximum temperature increased by 0.5°C.

The fourth scenario:

The average net return per feddan estimated when the maximum temperature increased by one Celsius degree.

The fifth scenario:

The estimated average net returns per feddan when the relative humidity decreases by 10%.

The sixth scenario:

The estimated average net return per feddan when the relative humidity increases by 10%.

The seventh scenario:

The estimated average net return per feddan when the amount of rain decreases by 5%.

The eighth scenario:

The average net return per feddan estimated when the amount of rain increases by 5%.

From Table (7), it was found that the positive effect of a decrease in minimum temperature of about (0.5, 1) Celsius degree on average net return per feddan for the winter tomato crop at a rate of about 30.2%, 35.9% compared to the average net return per feddan calculated from the model, and it was found that The negative effect of increasing the maximum temperature of about (0.5, 1) Celsius degree on the average net return per feddan for the tomato crop at a rate of about 12.1%, 2.7% compared to the average net return per feddan calculated from the model, while the negative effect of the lowering of Relative humidity of about 10% on average net return per feddan at a rate of about 9.9% compared to average net return per feddan of tomato calculated from the model, while the positive effect was found if the relative humidity increased by about 10% on average net return per feddan at a rate of about 25. 5% compared to the average net return per feddan calculated, and the positive effect was revealed by the decrease or increase in the amount of rain by about 5% on the average net return per feddan at a rate of about 23.1%, 27.3%, respectively, during The period (2000-2021).

From the previous presentation, we can conclude the following:-

The effect was positive in the case of a decrease in the minimum temperature by about 0.5, 1 Celsius degree.

- The effect was negative in the case of an increase in the maximum temperature by about 0.5, 1 Celsius degree.

The effect was negative in the case of a decrease in relative humidity by about 10%, and the effect was positive in the case of an increase in humidity by about 10%.

- The effect was positive in the event of a decrease or increase in the amount of Rainfall by about 5%

Therefore, the average net return per feddan of tomato is sensitive to the increase in maximum temperature and lowering humidity, and this indicates the necessity of choosing an appropriate location for growing and producing the winter tomato crop when the climate changes.

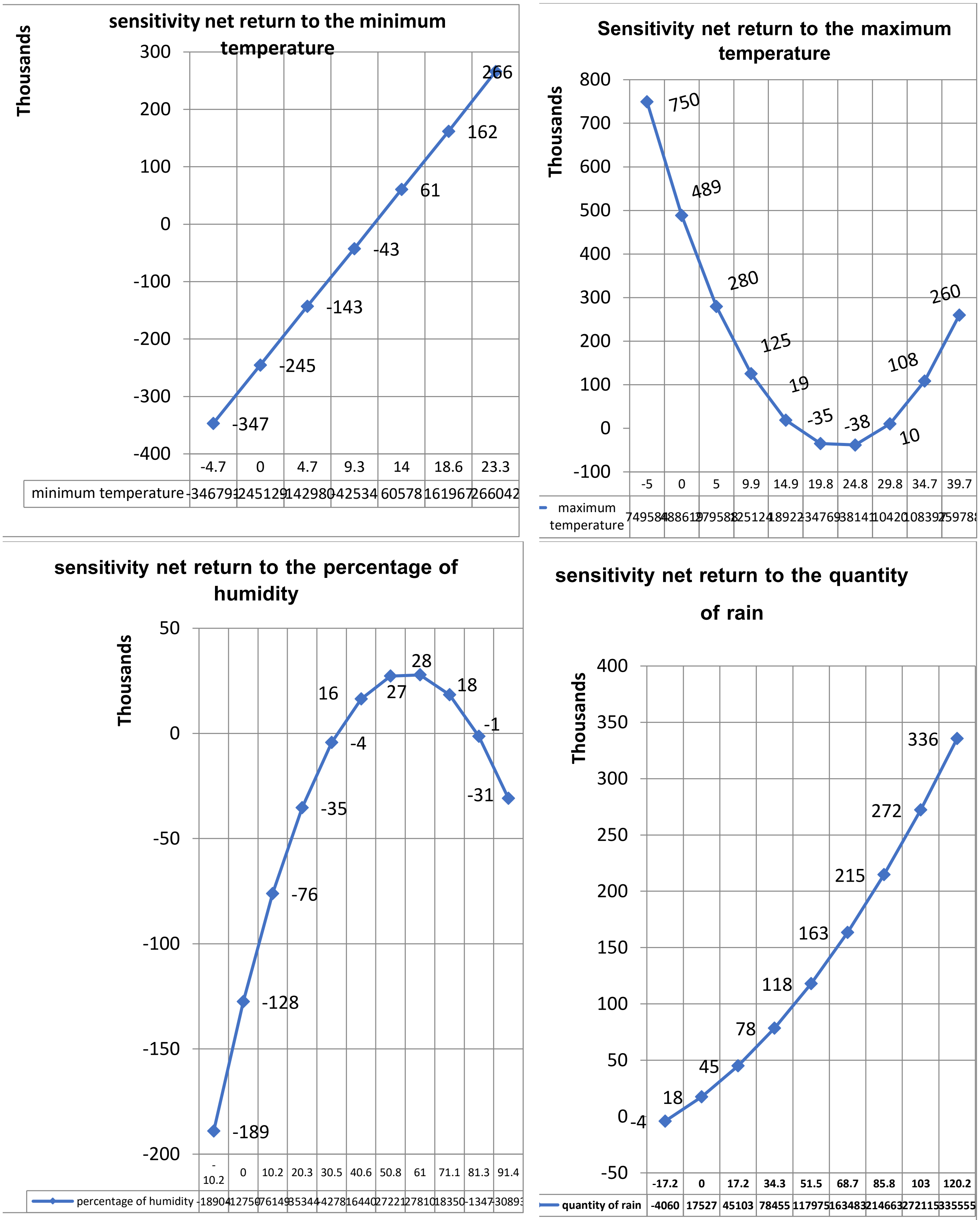

Figure (1) the effect of climate changes on the net feddan return of the winter tomato crop.
Source: calculated from table Data (5)

Table (7) Allergy Analysis of the effect of change in the climatic factors of tomatoes during the period (2000-2021)

Governorates /years	Current net return Egy. Pound	Calculated Net return	first scenario	second scenario	third scenario	fourth scenario	fifth scenario	Sixth scenario	seventh scenario	**eighth scenario**
			Minimum temperature (0.5)	Minimum temperature (1)	maximum temperature (0.5)	maximum temperature (1)	Relative humidity 10%	Relative humidity 10%	Rain quantity 5%	**Rain quantity5 %**
Ismailia	22665.5	22943.2	18279.2	19153.9	25153.9	27429.2	14216.1	20694.3	41818.4	44583.0
sharkia	18220.4	20199.9	36424.2	36740.4	13181.1	13743.6	24389.5	35235.9	18181.6	18274.9
noubaria	13168.5	27317.8	23302.3	24615.3	14860.0	17257.2	16656.5	23252.2	19533.0	19914.1
Beni suef	15110.0	15208.5	33516.8	35899.2	22071.2	24899.0	21890.1	28302.3	25913.2	26300.5
2000	3288.5	5845.7	7697.8	10384.0	7449.3	8999.2	2474.3	3819.0	5470.3	5531.5
2001	1702.8	-1820.8	7466.4	10225.2	13086.8	14086.7	11988.0	19486.5	13594.0	13504.9
2002	3235.7	4330.3	31461.5	31469.1	18255.6	18973.5	6821.7	13824.5	37157.9	39591.2
2003	6429.0	8436.7	269311.2	264824.5	-218412.6	-223951.5	83604.7	90601.6	-7792.9	-12711.8
2004	4587.4	4796.1	28916.5	32557.1	45324.4	45844.6	29564.6	52218.6	35213.4	35107.5
2005	1830.8	6944.9	25258.8	28362.2	23361.4	24480.1	15039.4	27466.7	20423.5	20535.8
2006	7158.8	13521.2	-62961.0	-65906.6	89775.8	87243.1	4812.6	12009.2	344.6	417.6
2007	7410.2	9581.9	5741.4	8715.4	10892.6	10768.2	1481.0	4841.5	13256.5	14117.6
2008	10816.9	10231.1	19145.0	20257.8	18300.4	18602.7	25527.6	20254.1	25320.1	26286.6
2009	6404.6	8256.9	79698.6	88898.5	24135.4	32085.8	41753.7	36729.8	48793.3	51391.2
2010	10550.0	9830.4	41808.3	45336.5	58837.5	61275.3	42080.4	62997.3	35317.4	35314.8
2011	26879.9	28054.6	-10307.0	-9041.5	41499.0	45550.5	9909.1	13998.4	17526.4	17382.1
2012	24747.8	24606.7	17426.1	15712.2	12589.8	14675.5	-74.1	5620.5	5066.9	5129.9
2013	26011.9	30232.7	8694.8	10237.9	39001.7	43048.2	4904.4	10289.4	14329.7	15564.6
2014	25532.6	28154.3	38392.9	44989.6	32795.6	42668.4	41073.4	31175.4	22472.2	19246.6
2015	25737.7	37611.2	-4741.4	-8777.6	84823.3	92675.4	16143.1	44661.1	30952.3	30980.9
2016	20179.9	33159.4	8363.7	7331.0	53098.5	57316.8	14765.6	39889.6	21515.6	21864.9
2017	26055.4	29113.7	-13230.7	-13050.1	5281.2	4048.7	8103.8	15981.5	3968.0	3872.8
2018	21704.3	35978.1	13522.2	13238.0	4022.1	4796.6	2558.7	10030.3	47210.4	51371.3
2019	23930.8	31027.0	25242.9	24849.8	423.6	989.4	19285.3	15024.1	35431.2	36668.9
2020	45596.4	48818.9	41990.0	41774.6	14394.5	16780.5	22054.5	21144.3	125916.7	140185.8
2021	50613.1	64470.4	34475.9	37860.7	35028.7	37351.8	20465.9	39102.1	28466.9	28544.2
Average	17291.1	21417.3	27880.6	29102.2	18816.6	20832.3	19288.1	26871.2	26361.6	27268.1
Rate of change		23.9	30.2	35.9	-12.1	-2.7	-9.9	25.5	23.1	27.3

Source: calculated from table Data (5)

Summary and recommendations:

The agricultural sector is considered one of the sectors that will be most negatively affected by the phenomenon of climate change. Climate changes are expected to affect the productivity of agricultural land, starting with affecting the natural, chemical and biological properties of the soil, passing through the spread of pests, insects, diseases and other problems, and ending with affecting the production of the crop. The tomato crop is one of the crops most affected by the very cold weather, and this leads to moving its prices higher, and this can be seen in the high prices of tomatoes in the markets at times that witness a noticeable drop in temperatures, which affects the production of the crop and thus leads to a shortage of supply in the market as a result of affected Plants with unstable climatic factors. The area planted with winter tomatoes amounted to about 192.43 thousand feddans, with a productivity of about 17.9 tons / feddan, with a total production of about 3436.7 thousand tons, with a net return estimated at about 16.73 thousand Egyptian pounds / feddan at the level of the Republic during the period (2000-2021). The problem lies in the impact of climate change on the productivity and quality of the tomato crop, which is one of the crops whose growth is affected by a temperature drop below 10 degrees Celsius.

The research aims to study the impact of climate change represented by changing the maximum and minimum temperatures, humidity and rainfall on feddan net return for the winter tomato crop. The maximum temperature in Sharkia Governorate during the period (2017-2021) reached its maximum at about 28.72 degrees it came in the month of July with about 36.06

degrees, with a index number of 125.5%, and its minimum reached about 19.04 degrees, it came in the month of January with a index numberr of about 66.3% The results of the one-way variance analysis of the average productivity of the winter tomato crop among the governorates of the Republic produced during the period (2016-2021) showed that there significant differences in the average productivity between the governorates, and this was explained by the presence of real differences between these governorates on the one hand and because of the effect of a factor On the other hand. when studying the Ricardo model of the effect of climatic changes on feddan net return for the winter tomato crop, it was found that there is an inverse relationship between the effect of both the average minimum temperature and the feddan net return for growth periods and square of the average minimum temperature for the planting period, It was found that the effect was negative in the case of a decrease in relative humidity of about 10% and positive in the case of an increase in humidity of about 10%. and it was also shown that there was an inverse relationship between the average maximum temperature and the feddan net return for both the growth period and the harvest period, while it was found that there was a direct relationship between both the average minimum temperature and its square on the one hand and the feddan net return for the planting period for both the growth period and the harvest period on the other hand, and also found an inverse relationship for the square of the average maximum temperature for each of the planting period, growth period and harvest period,

The study predicted several scenarios for the impact of climatic changes on feddan net return of the tomato crop It was found that the effect was positive in the case of a decrease in the minimum temperature by about 0.5 and 1 degree Celsius, and in the case of a decrease or increase in the amount of rain by about 5% and this only occurs outside the critical range of production whose range ranged between minimum and maximum which estimate to about 14.9-29.8 degrees Celsius.

We conclude that the net yield per feddan of the winter tomato crop is sensitive to both the increase in the maximum temperature and the lack of air humidity.

The search recommended:

1. It is preferable to plant winter tomatoes early because they cannot bear the low temperature and are considered warm weather plants, with the selection of the appropriate place and date of planting and the appropriate soil.
2. Developing new varieties that can withstand the change in climatic conditions, as well as expanding the cultivation under the greenhouse to avoid weather fluctuations.
3. Establishing an automated system for early weather warning and forecasting of risks to the tomato crop and other crops, and issuing recommendations to be followed to protect those crops.
4. Establishing an automatic system for early warning of diseases and insects associated with spreading under certain climatic conditions that may infect the tomato crop and other crops and how to avoid or limit them.
5. Training farmers on how to deal with climate changes, how to protect cultivated crops, and Training how to receive text messages and indicative videos through mobile phones from a private local information network maybe without the need for the Internet must be provided.
6. Creating a database for all agricultural crops on which information about those crops is stored and linked to farmers' mobile phones for easy access maybe without the need for the Internet.

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