Journal of American Science

Websites:
http://www.jofamericanscience.org
http://www.sciencepub.net

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

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

The impact of climate changes on the productive and economic efficiency of the wheat crop In the Arab Republic of Egypt (a case study in Dakahlia Governorate)

Dr. Tarek Mohamed Elsaed Abo-mosa and Dr. Elham Abdel M0aty Abbas

Senior Researcher, Agricultural Economics Research Institute, Agricultural Research Centre, Egypt

Abstract: Climate changes constitute one of the most important threats to sustainable development, and although Egypt is not one of the countries causing climate changes, it is one of the countries that has been greatly affected by these changes, especially the agricultural sector. The research problem is that climate changes cause a decline in the productivity of many crops in Egypt, especially the crop. Wheat, a decrease in wheat productivity in Dakahlia Governorate in conjunction with the presence of the phenomenon of excessive ears, as well as the small size and small number of grains in the ears of the crop, due to the negative effects of direct climate changes, which affects the total production of the wheat crop, as the cultivated area reached about 267.8 thousand acres as the average for the study period. The research aims primarily to study the impact of climate changes and rising temperatures on the productive and economic efficiency of the wheat crop. The study relied on descriptive and quantitative analysis methods to analyse both secondary and primary data. Primary data was obtained using stratified cluster sampling in Dakahlia Governorate. The study concluded that although the total production of the wheat crop in Egypt is increasing annually by 135.51 thousand tons, equivalent to 1.64% of its annual average of about 8247 thousand tons during the study period (2000-2022), the increase in acre productivity did not prove significant, which resulted in an increase in imports of the crop. Wheat in Egypt annually amounted to 410.4 thousand tons, equivalent to 5.19% of its annual average, due to the annual increase in consumption by 536.98 thousand tons, equivalent to 3.35% of its annual average during the study period. It was also shown that the self-sufficiency rate of the wheat crop in Egypt decreases annually by 0.97 %, equivalent to 1.7% of its annual average during the study period. The results of the research sample study confirmed that the cultivation of the wheat crop in the early period is greatly affected by climate changes, which is reflected in the increase in the quantities used of production requirements and the decrease in per-acre productivity of the main and secondary output by about 18.7%, 25%, and the value of both the total and net returns also decreased. The return was about 19.3% and 92.2% compared to planting at the recommended timing, respectively. This also affected the increase in the cost of producing ardeb by about 21.2%, a decrease in the net return of ardeb, the profit of the invested pound, the margin over variable costs, and the ratio of net return to costs. Variable, the ratio of the total return to the total costs is about 62.2%, 108.6%, 38.4%, 83.1%, and 37.3% for early plantings, respectively, and imposing scenarios to predict the negative effects on the crop of increasing temperature, and based on that, productivity and production are expected to decrease to reach about 2,499 tons and 9.794 million tons, respectively, in 2033. It is also expected that the amount of decrease in production in 2033 will reach about 1.25 million tons, but it will be compensated by reclaiming lands of about 501 thousand acres. The cost of their reclamation is estimated at about 150.3 billion pounds, equivalent to about 4.3 billion dollars, assuming the stability of the exchange rate during the forecast period, or through importing this shortfall in production by about 437.5 million dollars, and assuming that the import price of a ton of wheat remains constant during the forecast period.

[Tarek Mohamed Elsaed Abo-mosa and Elham Abdel M0aty Abbas. **The impact of climate changes on the productive and economic efficiency of the wheat crop In the Arab Republic of Egypt (a case study in Dakahlia Governorate)** Am Sci 2024;20(3):29-48]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org 06. doi:10.7537/marsjas200324.06.

Keywords: Climate change, Wheat yield, Production efficiency, Economic efficiency.

Introduction;

Climate change represents a major challenge locally and globally and may be an obstacle to achieving sustainable development in some economic sectors, especially the agricultural sector, as the increasing and continuous rise in temperatures, reduced rainfall, and some changes in other climatic factors may lead to waves of drought that have a negative impact. On agriculture in rainforest areas that depend entirely on rain by 75%, it has been observed that the productivity of agricultural crops in those places has decreased by a rate ranging between 10%-30%, and the percentage of decline is likely to reach 50% by the year 2050.

Egypt is considered an agricultural country, as the agricultural domestic product represents about 10.8% of the national gross domestic product, each amounting to about 477.6 and 4428.5 billion pounds, respectively, for the year 2022 at the market price (at constant prices) · and with the effects of negative climate changes on the agricultural sector in a major way. Directly on the productivity of agricultural crops, especially the basic strategic crops, including the wheat crop, and its impact on Egyptian food security, as Egypt is considered the largest wheat importing country in the world, as it will import about 9.177 million tons in 2022, representing 49.1% of what is available for consumption, amounting to about 18.691 million tons, to fill the gap. Therefore, it is necessary to provide an appropriate agricultural climate environment and to work constantly with research centres to address and mitigate the damage resulting from potential environmental changes, and to work to reduce the food gap to secure food, close the deficit in the general trade balance, provide food security, and achieve a decent, sustainable life for society.

Research problem:

The research problem is represented by the decline in wheat productivity in Dakahlia Governorate, coinciding with the phenomenon of excessive ears, as well as the small size and small number of grains in the ears of the crop, due to the negative effects of direct climate changes, which affects the total production of the wheat crop, as the cultivated area reached about 267.8 thousand acres as an average of the study period. Dakahlia is considered one of the leading agricultural governorates in the production of agricultural crops in general and wheat in particular, as Dakahlia's average wheat production represents 9.3% of the total wheat production in the Republic, which amounts to about 754 and 8247 thousand tons, respectively, as the average for the period 2000-2022. At a time when Egypt is suffering from a large deficit to fill the wheat food gap, as the rate of self-sufficiency in wheat reached about 53% on average during the study period, and with climate and environmental changes that are not accounted for by fluctuations in agricultural production in general and the wheat crop in particular, it is expected that the productivity of the wheat crop will decline and decline. In the coming years, the wheat food gap will increase due to climate change and the gradual rise in temperatures, which will result in an increase in the trade deficit, which reached about 801.69 billion pounds in 2022, which will result in an increased burden on the state's general budget.

Research objectives:

The research aims primarily to study the extent of the impact of climate changes and rising temperatures on the productive and economic efficiency of the wheat crop through studying several sub-objectives, namely studying the most important productive and economic variables of the wheat crop, which is considered one of the most important strategic commodities, and studying the development and seasonal index of the most important climate variables. And the extent of its impact on the planting and harvesting period of the wheat crop in Dakahlia Governorate, with a study of the extent of the impact of climate changes on the productive and economic efficiency of the wheat crop in the study sample in Dakahlia Governorate, by studying the impact of climate changes on the quantities of production elements used, as well as the impact of climate changes on production cost items and the most important economic indicators for the crop. Wheat according to the difference in planting dates, with a study of the most important production problems facing farmers, which are mainly due to the negative effects of climate changes, while imposing a set of expected scenarios for the negative effects of climate changes on wheat crop productivity and how to treat them.

Data sources and research method:

The study relied on published and unpublished secondary data that was obtained from official bodies such as the Central Agency for Public Mobilization and Statistics, the Ministry of Agriculture and Land Reclamation, the Economic Affairs Sector, the Directorate of Agriculture in Dakahlia Governorate, as well as the Central Climate Laboratory, as well as primary data in the study sample that It relied on the stratified cluster sampling method on wheat farmers in Dakahlia Governorate, in addition to some published research and studies in this field.

Descriptive and quantitative analysis methods were also relied upon to analyse the data and some statistical measurements to describe the various variables and their economic significance, in addition to some indicators and standards of technical-economic efficiency, as well as some scenarios to anticipate the negative effects of the impact of future climate changes and how to treat them to achieve the research goal.

Results:

First: The most important productive and economic indicators for the wheat crop in the Republic and Dakahlia Governorate during the period (2000-2022).

1-Productivity indicators for the wheat crop in the Republic during the period.

A. By studying Table (1), it is clear that the total area of the wheat crop in Egypt during the period (2000-2022) ranged between a minimum of about 2,341,795 thousand acres in 2001, equivalent to about 95.06% of what it was in 2000, and a maximum of about 3,419,427 thousand acres. In 2021, equivalent to 138.82% of what it was in 2000, with an annual average of about 3,019,424 thousand acres during that period.By estimating the general time trend in the development of the wheat crop area in Egypt during the study period, it is clear from Equation (1) and Table (2) that the cultivated area of wheat crop in Egypt is increasing annually by 44.24 thousand acres, equivalent to 1.47% of its annual average during the study period, and it has proven significant. This increase is statistically significant at a level of 0.01, and the coefficient of determination is about 0.85. 85% of the changes in the wheat crop area in Egypt are due to the time factor, and 15% of the changes are due to other factors not included in the model.

B- By studying Table (1), it is clear that the productivity of the wheat crop in Egypt during the period (2000-2022) ranges between a minimum of about 2,389 tons in 2010, equivalent to about 89.64% of what it was in 2000, and a maximum of about 2,882 tons in 2017, including It is equivalent to 108.14% of what it was in 2000, with an annual average of about 2,728 tons during that period. By estimating the general time trend in the development of wheat crop productivity in Egypt during the study period, it is clear from Equation. (2) Table (2) that wheat crop productivity in Egypt is increasing annually and this increase has not been proven statistically significant, which means that it is relatively constant at its annual average of about 2,728 tons during that period.

C - By studying Table (1), it is clear that the total production of the wheat crop in Egypt during the period (2000-2022) ranges between a minimum of about 6,254,583 thousand tons in 2001, equivalent to about 95.29% of what it was in 2000, and a maximum of about 9,842,272 thousand tons. In 2021, equivalent to 149.94% of what it was in 2000, with an annual average of about 8247.3 thousand tons during that period. By estimating the general time trend of the development of the total production of the wheat crop in Egypt during the study period, it is clear from Equation (3) Table (2) that the total production of the wheat crop in Egypt is increasing annually by 135.5 thousand tons, equivalent to 1.64% of its annual average during the study period, and the significance of this has been proven. The increase is statistically at a significance level of 0.01, and the coefficient of determination is about 0.85. 85% of the changes in wheat crop production in Egypt are due to the time factor, and 15% of the changes are due to other factors not included in the study.

2-Productivity indicators for the wheat crop in Dakahlia Governorate during the period (2000-2022)..

A-Studying Table (1) shows that the wheat crop area in Dakahlia Governorate during the period (2000-2022) ranged between a minimum of about 188,913 thousand acres in 2017, equivalent to about 73.74% of what it was in 2000, and a maximum of about 331,880 thousand acres in the year. 2006, equivalent to 129.55% of what it was in 2000, with an annual average of about 267.8 thousand acres, representing about 8.9% of the average area of the Republic during that period. By estimating the general time trend in the development of the area cultivated with wheat in Dakahlia during the study period, it is clear from Equation (4) Table (2) that the area of wheat crop in Dakahlia decreases annually, and this decrease has not been proven statistically significant, which means that it is relatively stable at its annual average of about 267.8 thousand acres.

B - By studying Table (1), it is clear that the productivity of the wheat crop in Dakahlia Governorate during the period (2000-2022) ranges between a minimum of about 2,547 tons in 2010, equivalent to about 83.84% of what it was in 2000, and a maximum of about 3,292 tons in 2017. Equivalent to 108.36% of what it was in 2000, with an annual average of about 2,868 tons, representing about 105.1% of the average wheat productivity in the Republic during that period.

By estimating the general time trend in the development of wheat crop productivity in Dakahlia during the study period, it is clear from Equation (5) Table (2) that wheat crop productivity in Dakahlia decreases annually, and this decrease has not been proven statistically significant, which means that it is relatively stable at its annual average of about 2.828 tons during that period. Period**.**

C- By studying Table (1), it is clear that the total production of the wheat crop in Dakahlia during the period (2000-2022) ranges between a minimum of about 609,947 thousand tons in 2001, equivalent to about 78.36% of what it was in 2000, and a maximum of about 932,915 thousand tons. In 2006, equivalent to 119.86% of what it was in 2000, with an annual average of about 765,665 thousand tons, representing about 9.3% of the average wheat production in the Republic during the study period. By estimating the general time trend in the development of the total production of the wheat crop in Dakahlia during the study period, it is clear from Equation (6) Table (2) that the production of the wheat crop in Dakahlia is decreasing annually, and the significance of this decrease has not been proven statistically, which means that it is relatively stable at its annual average of about 765.665 thousand tons during that period.

3-The most important economic indicators for the wheat crop in the Republic during the Period (2000-2022)

A- By studying the data presented in Table (3) of the development of the quantity of wheat imports during the study period (2000-2022), it was found that it ranged between a minimum of about 2.818 million tons in 2001, equivalent to about 65.5% of what it was in 2000, and a maximum of about 12.86 million tons in 2020, equivalent to 299% of what it was in 2000, with an annual average of about 7.894 million tons during that period, By estimating the general time trend in the development of imports of wheat in Egypt during the study period, it appears from Equation (7) Table (4) that imports of wheat in Egypt are increasing annually by 409.2 thousand tons, equivalent to 5.18% of their annual average during the study period, and it has proven significant. This increase was statistically significant at a level of 0.01, and the coefficient of determination reached about 0.91, meaning that 91% of the changes that occur in imports of the wheat crop in Egypt are due to the time factor, and 9% of the changes are due to other factors that were not included in the study.

Table (1): The most important indicators of wheat crop production in the Republic and Dakahlia Governorate and their relative importance during the period (2000-2022).

Statement / Years	Republic						Dakahlia Governorate					
	Area		Productivity		Production		Area		Productivity		Production	
	One thousand Acres	%	Tons	%	One thousand tons	%	One thousand Acres	% of the Republic	Tons	% of the Republic	One thousand tons	%of the Republic
2000	2463.27	100	2.665	100	6564.05	100	256.18	10.4	3.038	114	778.35	11.9
2001	2341.8	95	2.671	100	6254.58	95	210.69	9	2.895	108.4	609.95	9.8
2002	2450.43	99	2.704	101	6624.87	101	221.04	9	2.903	107.4	641.57	9.7
2003	2506.18	102	2.731	102	6844.69	104	246.65	9.8	2.883	105.6	711.09	10.4
2004	2605.48	106	2.755	103	7177.86	109	261.47	10	2.949	107	771.06	10.7
2005	2985.29	121	2.727	102	8140.96	124	304.84	10.2	2.848	104.4	868.34	10.7
2006	3063.7	124	2.701	101	8274.23	126	331.88	10.8	2.811	104.1	932.92	11.3
2007	2715.53	110	2.717	102	7378.92	112	272.6	10	2.844	104.7	775.27	10.5
2008	2920.38	119	2.732	102	7977.05	122	290.31	9.9	2.868	105	832.46	10.4
2009	3147.03	128	2.708	101	8523	130	307.17	9.8	2.853	105.4	876.36	10.3
2010	3001.38	122	2.389	89	7169.02	109	296.39	9.9	2.547	106.6	754.91	10.5
2011	3048.6	124	2.746	103	8370.53	128	300.03	9.8	2.789	101.6	836.62	10
2012	3160.66	128	2.783	104	8795.48	134	303.29	9.6	2.899	104.2	879.24	10
2013	3377.88	137	2.801	105	9460.2	144	302.25	8.9	2.648	94.5	800.21	8.5
2014	3393	138	2.735	102	9279.8	141	291.86	8.6	2.85	104.2	831.8	9
2015	3468.86	141	2.77	104	9607.74	146	273.31	7.9	2.883	104.1	787.96	8.2
2016	3353.15	136	2.786	104	9342.54	142	268.35	8	3.078	110.5	825.98	8.8
2017	2921.72	119	2.882	108	8421.07	128	188.91	6.5	3.292	114.2	621.86	7.4
2018	3156.84	128	2.645	99	8348.63	127	240.12	7.6	2.904	109.8	697.38	8.4
2019	3134.95	127	2.73	102	8558.81	130	223.57	7.1	2.786	102.1	622.83	7.3
2020	3394.19	138	2.684	101	9108.48	139	263.32	7.8	2.767	103.1	728.7	8
2021	3419.43	139	2.878	108	9842.27	150	242.3	7.1	2.769	96.2	671.03	6.8
2022	3417.02	139	2.816	105	9622.99	147	262.88	7.7	2.87	101.9	754.42	7.8
Mean	3019.42	123	2.728	102	8247.29	126	267.8	8.9	2.868	105.1	765.67	9.3
Minimum	2341.8		2.39		6254.58		188.91		2.55		609.95	
Maximum	3468.8		2.88		9842.27		331.88		3.29		932.92	

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

Table (2): The general time trend for the most important wheat production indicators in the Republic and Dakahlia Governorate during the period (2000-2022).

Number		Dependent variable	Equation	Mean	T	F	R	Rate of change
the Republic	1	Wheat area	$\hat{Y}_1 = 2488.565 + 44.238x$	3019.42	(7.345)**	(53.95)**	0.85	1.47
	2	Wheat productivity	$\hat{Y}_2 = 2.670 + 0.005x$	2.729	(1.686)	(2.84)	0.35	-
	3	Wheat production	$\hat{Y}_3 = 6621.360 + 135.499x$	8247.3	(7.331)**	(53.7)**	0.85	1.64
Dakahlia	4	Wheat area	$\hat{Y}_4 = 274.587 - 0.566x$	267.80	(- 0.494)	(0.244)	0.11	-
	5	Wheat productivity	$\hat{Y}_5 = 2.885 - 0.001x$	2.868	(- 0.296)	(0.09)	0.06	-
	6	Wheat production	$\hat{Y}_6 = 790.364 - 2.058x$	765.67	(- 0.712)	(0.51)	0.15	-

Source: Calculated from data in Table (1) of the study, **where**: ** indicates a significance level of 0.01.

B- By studying the data in Table (3) of the development of the wheat crop available for consumption in Egypt during the period (2000-2022), it was found that it ranged between a minimum of about 9.819 million tons in 2001, equivalent to about 88.13% of what it was in 2000, and a maximum of about 21.482 million tons in 2020, equivalent to 192.8% of what it was in 2000, with an annual average of about 15.951 million tons. By estimating the general time trend in the development of the available for consumption of the wheat crop in Egypt during the study period, it became clear from Equation (8) Table (4) that the available for consumption The wheat crop in Egypt increases annually by 512.1 thousand tons, equivalent to 3.2% of its annual average for the study period. This increase has been proven statistically significant at a significance level of 0.01, and the coefficient of determination is about 0.97, meaning that 97% of the changes in wheat are available for consumption. In Egypt, it is due to the time factor, and 3% of the changes are due to other factors that were not included in the study.

C- By examining the data in Table (3) of the development of the self-sufficiency rate of the wheat crop in Egypt during the period (2000-2022), it was found that it ranged between a minimum of about 41.06% in 2019, equivalent to about 63.7% of what it was in 2000, and a maximum of about 63.7. % in 2001, equivalent to about 108.1% of what it was in 2000, with an annual average of about 53.05%. By estimating the general time trend of the development of the self-sufficiency rate of the wheat crop in Egypt during that period, it is clear from Equation (9) Table (4) that the self-sufficiency rate of the wheat crop in Egypt decreases annually by 0.847%, equivalent to 1.6% of its annual average during the study period. The significance of this decrease was proven statistically at a significance level of 0.01, and the coefficient of determination reached about 0.82, meaning that 82% of the changes in the wheat self-sufficiency rate in the Republic are due to the time factor, and 18% of the changes are due to other factors that were not included in the study.

D- By studying the data presented in Table. (3) of the evolution of the size of the food gap (deficit) in the wheat crop in Egypt during the period (2000-2022), it was found that it ranged between a minimum of about 3.564 million tons, equivalent to about 57% of production in 2001, to about 77 9% of what it was in 2000, and a maximum of about 12.374 million tons, equivalent to about 135.8% of production in 2020, about 270.3% of what it was in 2000, with an annual average of about 7.704 million tons, equivalent to about 91.9% of average production. During that period, by estimating the general time trend of the development of the food gap (deficit) of the wheat crop in Egypt during the study period, it became clear from Equation (10) Table (4) that the food gap (deficit) of the wheat crop in Egypt is increasing annually by 376.6 thousand tons, or by 4.9% of the annual average during the study period. This increase was proven statistically significant at a significance level of 0.01, and the coefficient of determination reached about 0.93, meaning that 93% of the changes in the food gap (deficit) of the wheat crop are due to the time factor, and that 7% of the changes It is due to other factors that were not included in the study.

Table (3): The most important economic indicators for the wheat crop in the A.R. of Egypt during the period (2000-2022).

Statement / Years	Production (thousand tons)	Imports (thousand tons)	Available for consumption (thousand tons)	%Self-sufficiency*	Gap (deficit)** (thousand tons)	%From production
2000	6564	4302	11141	58.9	4577 -	69.73
2001	6255	2818	9819	63.7	3564 -	56.98
2002	6625	4531	11625	57.0	5000 -	75.47
2003	6845	4065	10936	62.6	4091 -	59.77
2004	7178	4367	11754	61.1	4576 -	63.75
2005	8141	5773	13353	61.0	5212 -	64.02
2006	8274	5820	14257	58.0	5983 -	72.31
2007	7379	5911	13773	53.6	6394 -	86.65
2008	7977	7381	14546	54.8	6569 -	82.35
2009	8523	6372	14225	59.9	5702 -	66.9
2010	7169	7938	14978	47.9	7809 -	108.9
2011	8371	9811	16878	49.6	8507 -	101.6
2012	8795	6549	15657	56.2	6862 -	78.02
2013	9460	7878	17210	55.0	7750 -	81.92
2014	9280	8126	17025	54.5	7745 -	83.46
2015	9608	9001	18411	52.2	8803 -	91.62
2016	9343	10820	19411	48.1	10068 -	107.8
2017	8421	12061	20019	42.1	11598 -	137.7
2018	8349	12390	19714	42.4	11365 -	136.1
2019	8559	12493	20847	41.1	12288 -	143.6
2020	9108	12864	21482	42.4	12374 -	135.9
2021	9842	11116	21121	46.6	11279 -	114.6
2022	9623	9177	18691	51.5	9068 -	94.23
Mean	8247	7894	15951	53.1	7704 -	91.9
Minimum	6255	2818	9819	41.1	3564 -	143.6
Maximum	9842	12864	21482	63.7	12374 -	56.98

Where: * Self-sufficiency ratio = (total production ÷ total consumption) x 100.
** Size of the gap = production - available for consumption.
Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Food Balance Bulletin, various issues.

Table (4): General trend equations for the development of economic indicators for the wheat crop in Egypt during the period(2022-2000)

Number	Dependent variable	equation	Mean	T	F	R	rate of change
7	Wheat imports	$\hat{Y}_7 = 2983.419 + 409.22x$	7894.1	(10.28)**	(105.6)**	0.91	5.18
8	Available for consumption	$\hat{Y}_8 = 9806.395 + 512.05x$	15951	(17.42)**	(303.6)**	0.97	3.21
9	Self-sufficiency%	$\hat{Y}_9 = 63.221 - 0.847x$	53.1	(- 6.67)**	(- 44.4)**	0.82	- 1.59
10	Gap (thousand tons)	$\hat{Y}_{10} = 3185.036 + 376.55x$	7703.7	(11.2)**	(125.8)**	0.93	4.88

Source: Collected and calculated from data in Table 3 of the study, where: ** indicates a significance level of 0.01.

Second: Study the developments and seasonal index of the most important climate variables in Dakahlia Governorate during the period (2000-2022).

A- Maximum and minimum temperatures: Studying the evolution of maximum and minimum temperatures in Dakahlia Governorate during the period (2000-2022). It was shown from the data in Table (5) that the maximum temperatures ranged between a minimum of about 27.18 degrees Celsius in 2015 and a maximum of about 29.12 degrees Celsius in 2018 and 2019, with an annual average of about 27.89 degrees Celsius. It was also shown that the minimum temperatures ranged between A minimum of about 13.81 degrees Celsius in 2001 and a maximum of about 16.63 degrees Celsius in 2010, with an annual average of about 14.74 during the study period**.**

It was also shown from the data in Table (6) that the average maximum temperatures during the months of planting and harvesting of the wheat crop increased for each of the months of October, November, April, and May, with temperatures reaching about 29.75, 25.41, 27.88, and 31.84 over the general average for these months, which was about 24,935, with a record number of about 119.34, 101.93, 111.84, and 127.72, respectively. It was also found that the minimum temperatures increased from the general average of about 11.759 for the months of October, November, April, and May, with temperatures of 17.01, 13.67, 12.63, and 16.46 degrees Celsius, with a record number of about 147.01, 116.4, 107.48, and 140.02 degrees Celsius, respectively.

By estimating the general time trend of the evolution of the average maximum and minimum temperatures in Dakahlia Governorate during the study period, it became clear from equations Nos. (11 and 12) Table (7) that the maximum and minimum temperatures in Dakahlia are increasing annually by 0.043, 0.102 degrees Celsius, representing 0.15%, 0.69% over the ranking is based on their annual average during the study period. The significance of this increase has been proven statistically at a significance level of 0.01. The coefficient of determination reached about 0.54 and 0.77, meaning that 54% and 77% of the changes in the maximum and minimum temperature levels in Dakahlia are due to the time factor. 46% and 23%, respectively, of the changes in each of them are due to other factors not included in the analysis.

B- The amount of rainfall: By studying the data in Table (5) of the evolution of the average amount of rainfall in Dakahlia Governorate during the study period (2000-2022), it was found that it ranged between a minimum of about 0.7 mm/month in 2021 and a maximum of about 9.57 mm. /month of the year 2009, with an annual average of about 3.99 mm/month during the study period. It is also clear from the data in Table (6) that the average amount of rain during the months of planting and harvesting of the wheat crop increases during the months of December, January, February, and March in amounts amounting to about 6.92, 9.65, 7.24, 6.18 mm/month above the general average of about 5.475 during the months of planting and harvesting wheat, with a record number of 126.43, 176.42, 132.29, 112.99 mm/month, respectively.

By estimating the general time trend of the development of the average annual rainfall amount in the governorate, it is clear from Equation (13) Table (7) that the average annual rainfall amount in Dakahlia decreases annually by 0.186 mm/month, representing 4.66% of its annual average of about 3.99 mm/month. month, and the significance of this decrease was proven statistically at a significance level of 0.01, and the coefficient of determination reached about 0.58, meaning that 58% of the changes that occur in the average amount of annual rainfall in Dakahlia Governorate are due to the time factor, and 42% of the changes are due to other factors that were not included in the study.

C- Relative humidity:

By studying the evolution of the average relative humidity in Dakahlia Governorate, Table (5), it is clear that the relative humidity ranged between a minimum of about 58.21% in the years (2018 and 2020) and a maximum of about 73.83% in 2009, with an annual average of about 66.49% during Study period (2000-2022).

It was also shown from the data in Table (6) that the relative humidity increases during the months of December, January, February, and March by 69.26, 68.26, 71.52, 69.60 over the general average of about 66.255% for the period of planting and harvesting the crop, with a record number of 104.54, 103.03, 107.95. 105.06 respectively.

By estimating the general time trend of the evolution of the average relative humidity in Dakahlia Governorate during the study period, it is clear from Equation (14) Table (7) that the average relative humidity in Dakahlia decreases annually by 0.300%, which represents about 0.45% of its annual average of about 66.49%, and it may prove This decrease is statistically significant at a significance level of 0.05, and the coefficient of determination reached about 0.51, meaning that 51% of the changes in the average relative humidity in Dakahlia are due to the time factor, and 49% of the changes are due to other factors that were not included in the study.

Table (5): Evolution of maximum and minimum temperatures, rainfall amounts, and relative humidity in Dakahlia Governorate during the period (2000-2022).

Statem / Years	Maximum temperatures	Minimum temperatures	Rainfall amount in mm/month	Relative humidity%
2000	27.633	13.817	4.56	67.58
2001	27.625	13.808	4.56	67.58
2002	27.575	13.850	5.78	67.67
2003	27.575	13.842	5.78	67.67
2004	27.575	13.850	5.78	67.67
2005	27.575	13.850	5.78	67.67
2006	27.508	13.842	4.43	68.17
2007	27.575	13.850	4.58	67.67
2008	27.590	13.842	4.43	68.17
2009	27.575	13.850	9.57	73.83
2010	28.767	16.633	1.32	69.58
2011	27.750	15.417	5.12	70.67
2012	27.750	15.417	5.12	70.67
2013	27.817	15.117	2.20	61.30
2014	27.842	14.308	1.40	65.75
2015	27.175	15.333	7.20	67.00
2016	28.233	15.383	2.56	66.08
2017	27.583	14.917	1.80	68.00
2018	29.117	15.758	1.90	58.21
2019	29.117	15.758	1.70	58.25
2020	28.750	15.808	3.40	58.21
2021	28.083	15.417	0.70	65.83
2022	28.650	15.660	2.21	66.00
Mean	27.896	14.740	3.99	66.49
Minimum	27.180	13.810	0.70	58.21
Maximum	29.120	16.630	9.57	73.83

Source: Central Agency for Public Mobilization and Statistics, Annual Statistical Bulletin (Geography and Nature), various issues.

Table (6): A season record for the most important climate variables during planting and harvesting of the wheat crop during the period (2000-2022).

Months of planting and harvesting wheat	Maximum temperatures		Minimum temperatures		Rainfall amount in mm/month		Relative humidity %	
	Monthly average	**Seasonal guide**	**Monthly average**	**A season record**	**Monthly average**	**A season record**	**Monthly average**	**A season record**
October	29.757	119.34	17.287	147.01	3.847	70.265	64.043	96.66
November	25.417	101.93	13.687	116.4	5.105	93.242	66.913	100.99
December	22.222	89.12	9.491	80.713	6.922	126.43	69.261	104.54
January	18.078	72.501	6.965	59.231	9.659	176.42	68.261	103.03
February	20.765	83.277	7.809	66.409	7.243	132.29	71.521	107.95
March	23.509	94.281	9.726	82.711	6.186	112.99	69.609	105.06
April	27.887	111.84	12.639	107.48	2.665	48.676	61.957	93.513
May	31.848	127.72	16.465	140.02	2.169	39.616	58.478	88.262
General average	24.935	100	11.759	100	5.475	100	66.255	100

Source: Collected and calculated from data from the Central Agency for Public Mobilization and Statistics, Annual Statistical Bulletin (Geography and Nature), various issues.

Table (7): General time trend equations for the average evolution of various climate variables in Dakahlia Governorate during the period (2000-2022).

Number	Dependent variable	Equation	Mean	T	F	R	rate of change
11	maximum temperatures average	$\hat{Y}_{11}$= 27.386 + 0.043 x	27.9	(2.929)**	** (8.58)	0.54	0.15
12	minimum temperatures average	$\hat{Y}_{12}$= 13.523 + 0.102 x	14.74	(5.44)**	** (29.6)	0.77	0.69
13	Rainfall amount in mm/month	$\hat{Y}_{13}$ = 6.229 - 0.186 x	3.99	(- 3.22) **	(10.39)**	0.58	- 4.66
14	Relative humidity%	$\hat{Y}_{14}$ = 70.093 – 0.300 x	66.49	(- 2.727)*	(7.43)*	0.51	- 0.45

Where: ** significant at 0.1, * significant at 0.5. **Source:** collected and calculated from Table (1) of the study.

From the above it is clear that the maximum and minimum temperatures took a general increasing trend during the study period at a time when both rainfall rates and relative humidity decrease, which will negatively and directly affect agriculture in general and the decrease in wheat crop productivity. It was also clear that the rise in temperatures during the months of October until mid-November, which affects the decrease in the germination rate at that time.

D- A standard analysis of the impact of climate factors during the planting and harvesting months on the productivity of the wheat crop in Dakahlia:

By studying Table (8), Equation (15), it is shown that by conducting a multiple regression analysis of the explanatory variables {x_1 the maximum temperature, x_2 the minimum temperature, x_3 the amount of rainfall, and x_4 the relative humidity} during the months of planting and harvesting of the wheat crop in the governorate during the period (2000-2022) and the extent of their combined effect on crop productivity. It was found that there is a significant inverse relationship between wheat productivity and both the maximum temperature and relative humidity, and a non-significant relationship between the minimum temperature and a direct relationship between productivity and the amount of rainfall. The adjusted coefficient of determination was about 0.46, meaning 46% of the changes in productivity Wheat yield is due to all explanatory factors combined.

Table (8): Standard analysis of climate variables and their impact on wheat crop productivity in Dakahlia during the period (2000-2022).

Number	Multiple Regression Standard	F	R^{-2}
15	$Y = 6.774 - 0.112 X_1 - 0.011 X_2 + 0.002 X_3 - 0.015 X_4$ (6.373)** (-2.198)* (-0.24) (0.183) (-3.527)**	5.7**	0.46

Where: (x1, x2, x3, x4) average climate variables in the months of planting and harvesting the crop in Dakahlia Governorate during the period (2000-2022).
Y = average wheat crop productivity in the governorate during the study period
**Significant at 0.01 level of significance, *Significant at 0.05 level of significance, numbers in parentheses are t value
Source: Collected and calculated from Table (1) of the study and monthly climate data for the governorate of Al-Daqhaliyah

Third: **Climate changes and their impact on the productive and economic efficiency of the wheat crop in the study sample in Dakahlia Governorate for the agricultural season (2022/2023).**

Study sample in Dakahlia Governorate:

Dakahlia Governorate includes 12 administrative centres. The area cultivated with wheat in Dakahlia Governorate during the 2022/2023 agricultural season was approximately 272,396 thousand acres. The centres of Balqas and Mansoura were chosen from among the centres of Dakahlia Governorate. The villages of Al-Satamouni and Al-Masara Thani were chosen as the centre of Balqas, and the villages of Badin and the Mahal of Daman were chosen as the centre. Mansoura, where the sample size was distributed according to the relative importance of both the number of holders and the cultivated area, and according to the geometric mean and the modified geometric mean for the area and the number of holders of the wheat crop, and from counting the farmers in the register of agricultural cooperative societies for the sample villages, the farmers were selected according to random tables and according to the number specified for the study, and thus the sample becomes Stratified cluster, the sample size was estimated in the selected centres using the following equation[8]

$$n = \frac{\mathbf{N} \times \boldsymbol{P}(\mathbf{1} - \boldsymbol{P})}{\{(\mathbf{N} - \mathbf{1} \times (\mathbf{d}^2 \div \mathbf{z}^2)] + \boldsymbol{P}(\mathbf{1} - \boldsymbol{P})\}}$$

Where:

n: sample size N: Population size

Z: Confidence level at 95% (1.96)

d: Error proportion (0.05) P: Probability (50%)

Table (9): Sample size of wheat crop in selected villages in Dakahlia Governorate during the agricultural season (2022/2023)

Centre	Selected villages	Holders		Cultivated area		Geometric mean (1)	Modified geometric mean (2)	Sample size (3)
		Number	%	Fadan	%			
Balgas	**Stamouni**	2909	4.48	2203.8	5.73	5.07	34.8	134
	Masara thani	1271	1.96	1691.11	4.41	2.94	20.2	78
	Total	4180	6.44	3894.18	10.14	8.11	55.7	212
Mansoura	**Bedin**	3342	3.23	1081.12	3.5	3.36	23.1	88
	Mahal of Daman	3060	2.9	1007.13	3.29	3.09	21.2	84
	Total	6402	5.32	2088.25	6.34	6.45	44.3	172
Total		10582		5982.43	-	14.56	100	384

Where: (1) The geometric mean = the square root of the product of the relative importance of both the number of holders and the cultivated area.

(2) Adjusted geometric mean = geometric mean for each village / total geometric mean * 100.

(3) Number of sample members = adjusted geometric mean for each village * total sample size / 100.

Source: Agricultural Administration of Balqa's Central District, Mansoura, Dakahlia Governorate, "unpublished data"

By studying Table (9), it becomes clear that the total sample size is about 384 observations for the two sample categories, 212 observations in the Balqas centre, including 134 observations in the village of Stamouni, 78 observations in the village of Al-Masara Thani, and 170 observations in the Mansoura centre, including 88 observations in the village of Badin and 84 in the village of Daman district (note that both of the basic sample The comparison sample is 192 observations from the two centre villages and includes both sample categories).

Through the study sample, the impact of climate changes on the economics of wheat production in Dakahlia Governorate is measured through comparison between the two categories of the study sample, the basic sample (early agriculture) which includes the group of farmers who farmed during the period 15/10 - 15/11, and the comparison sample (agriculture Recommended) includes the group of farmers who planted during the period 15/11 - 15/12 for the same agricultural season 2022/2023, for each of the quantities used of production requirements, production cost items and the most important economic and productivity indicators, taking into account that the variety grown for the two samples is the same, Ceteris paribus.

1- The impact of climate changes on the quantities of production factors used to produce the wheat crop for the two categories of the study sample according to the difference in planting dates in Dakahlia for the agricultural season (2022/2023).

1- Quantity of seeds:

It is clear from Table (10) that the average quantity of seeds used to grow the wheat crop for the basic category (early cultivation) in the study sample was about 82.3 kg/acre, while for the comparison category (recommended cultivation) it was about 61.5 kg/acre, with a decrease It is estimated at about 20.8 kg/acre, with a reduction rate of about 25.3%. By testing the significance of the difference in the amount of seeds used between the basic and comparative study categories using a T-test, its significance was found at a significance level of 1%.

2-Quantity of nitrogen fertilizer:

It is clear from the data in Table (10) that the average amount of nitrogen fertilizer used to produce the wheat crop for the basic category in the study sample was about 94.2 nitrogen units/acre, while for the comparison category it was about 80.6 nitrogen units/acre, with an estimated decrease of about 13.6 units. Nitrogen/acre, at a rate of decrease of about

14.4%, and by testing the significance of the difference in the amount of nitrogen fertilizer used between the basic and comparative study groups using a T-test, its significance was found at a significance level of 5%.

3-Quantity of phosphate fertilizer:

It is also clear that the average quantity of phosphate fertilizer used to produce the wheat crop for the basic category in the study sample was about 25.5 phosphate units/acre, while for the comparison category it was about 19.8 phosphate units/acre, with an estimated decrease of about 5.7 phosphate units/acre, at a rate of decline. It amounted to about 22.4%, and by testing the significance of the difference in the amount of phosphate fertilizer used between the basic and comparison study groups using a T-test, its significance was found at a significance level of 1%.

4-Quantity of municipal fertilizer:

It is also clear that the average amount of municipal fertilizer used to produce the wheat crop for the basic category in the study sample was about 5.3 m3, while for the comparison category it was about 4.5 m3, a decrease estimated at about 0.8 m3, with a decrease rate of about 15.1%, and by testing the significance of the difference in The amount of municipal fertilizer used between the main and comparative study groups using a T-test shows its significance at the level of 5%, Table (10).

5-Chemical control and nutrients:

It is clear that the average amount of pesticides and nutrients used to produce the wheat crop for the basic group in the study sample was about 6.5 litters, while for the comparison group it was about 3.3 liters, an estimated decrease of about 3.2 liters, with a decrease rate of about 49.2%, and by testing the significance of the difference in the quantity used. Of pesticides and nutrients between the main and comparative study groups using a T-test showed its significance at the 1% level of significance, Table (10).

6- Machine work (number of tractors working hours):

The average number of working hours for the machine used to produce the wheat crop for the basic category in the study sample was about 11.4 hours, while for the comparison group it was about 10.4 hours, with an estimated decrease of about 0.6 hours, with a decrease rate of about 5.3%. By testing the significance of the difference in the number of working hours of the machine used between the main and comparative study categories using a T-test, it was found to be non-significant at the 5% significance level, Table (10).

7- Human work:

The average number of human working hours used to produce the wheat crop for the basic group in the study sample was about 21.5 men/day, while for the comparison group it was about 20.4 men/day, an estimated decrease of about 1.1 men/day, with a decrease rate of about 5.1%. By testing the significance of the difference in the number of human works between the main and comparative study categories using a T-test, it was found to be non-significant at the 5% significance level, Table (10).

8-Number of irrigation hours:

It is clear that the average number of irrigation hours in wheat crop production for the basic category in the study sample was about 17.6 hours, while for the comparison category it was about 14.5 hours, a decrease estimated at about 3.1 hours, at a rate of about 17.6%, and by testing the significance of the difference in the number of irrigation hours Used between the main and comparative study categories using a T-test, its significance was found at a 5% significance level,

9- Quantity of irrigation water:

It also appears that the average amount of irrigation used to produce the wheat crop for the basic category in the study sample is about 2560 m3, while for the comparison category it was about 2155 m3, a decrease estimated at about 405 m3, with a decrease rate of about 17.1%, and by testing the significance of the difference in the amount of water. The irrigation used between the main and comparative study groups using a T-test shows its significance at the 5% level of significance, Table (10).

From the above, it is clear that planting the wheat crop at an early date is greatly affected by climate changes, which is reflected in the increase in the quantities used for production requirements, especially the quantities of seeds and nitrogen-phosphate fertilizers, as the high temperatures at that time cause a weak germination rate and the absence of a percentage of seeds and a lack of The degree of benefit from nitrogen and phosphate fertilizers and the loss of a percentage of them, which forces farmers to increase the quantities used to compensate for this deficiency. It also results in an increase in the quantities used of pesticides due to the increase in insect and fungal infections, as well as an increase in the rates of use of foliar nutrients to compensate for weak germination and growth. It also results in This also requires an increase in the number of irrigation hours and the amounts of irrigation water used as a result of the land drying up quickly, which forces farmers to increase the number of irrigations compared to farmers who planted at the recommended times.

Table (10): Comparative analysis of the impact of climate changes on the quantities of production factors used to produce the wheat crop for the two categories of the study sample according to the difference in planting dates in Dakahlia Governorate for the agricultural season (2022/2023)

Production elements	Planting time (basic category (15/10 - 15/11)	Planting time (comparative category(15/11- 15/12)	Difference	Rate of change %	T value
Quantity of seeds(kg)	82.3	61.5	-20.8	-25.3	6.33**
Nitrogen fertilizer (unit)	94.2	80.6	-13.6	-14.4	3.25*
Quantity of phosphate fertilizer (unit)	25.5	19.8	-5.7	-22.4	5.56**
Quantity of municipal fertilizer m3	5.3	4.5	-0.8	-15.1	4.72*
Chemical control and nutrients (L)	6.5	3.3	3.2-	-49.2	9.56**
Automated work (number of tractor hours)	11.4	10.8	0.6-	-5.3	1.64
Human work (man/day)	21.5	20.4	-1.1	-5.1	1.88
Number of irrigation hours	17.6	14.5	-3.1	-17.6	5.32*
Quantity of irrigation water (m3)	2560	2155	-405	-17.1	5.21*

Source: Collected and calculated from the results of the questionnaire in Dakahlia Governorate in 2023, *significant at 5% **significant at 1%.

2-The impact of climate changes on the production cost items for the wheat crop for the two categories of the study sample according to the difference in planting dates in Dakahlia for the agricultural season (2022/2023).

Table (11) shows the items of wheat production costs in Dakahlia, with an explanation of the relative importance of each, for the basic sample (early planting) and the comparison sample (recommended planting)

It is clear that the average total costs of producing the wheat crop for the two study groups amounted to about 18,795 and 17,570 pounds per acre, respectively, with a decrease for the comparison sample of about 1,225 pounds per acre, representing about 6.5% of its value in the basic sample, while the variable costs amounted to about 9,565 and 8,370 pounds per acre for each of the sample. The basic and comparison costs, respectively, represent about 50.9% and 47.6% of the total costs for each of them, respectively, with a decrease for the comparison sample amounting to about 1195 pounds per acre, representing about 12.5% of its value in the basic sample.

The most important items of variable costs amounted to about 985.740 pounds per acre for both the basic and comparison sample, respectively, representing about 5.2% and 4.2% of the total costs for the two samples, respectively, with a decrease for the comparison sample amounting to about 245 pounds per acre, representing about 24.9% of its value. For the basic sample, the value of the nitrogen fertilizer was about 1,800 and 1,570 pounds per acre for both the basic and comparison sample, respectively, representing about 9.6% and 8.9% of the total costs for the two samples, respectively, with a decrease for the comparison sample amounting to about 230 pounds per acre, representing about 12.8% of its value for the basic sample. The value of phosphate fertilizer was about 320.400 pounds per acre for both the basic and comparison sample, respectively, representing about 2.1% and 1.8% of the total costs for the two samples, respectively, with a decrease for the comparison sample of about 80 pounds per acre, representing about 20% of its value for the basic sample. Municipal fertilizer is about 660 and 560 pounds per acre for both the basic and comparison sample, respectively, representing about 3.5% and 3.2% of the total costs for the two samples, respectively, with a decrease for the comparison sample of about 100 pounds per acre, representing about 15.2% of its value for the basic sample, and the value of pesticides was About 500 and 250 pounds were used per acre for both the basic and comparison sample, respectively, representing about 2.7% and 1.4% of the total costs for the two samples, respectively, with a decrease for the comparison sample amounting to about 250 pounds per acre, representing about 50% of its value for the basic sample.

It also becomes clear that while the cost of working the machine amounted to about 2,300 and 2,150 pounds per acre for both the basic and comparison sample, respectively, representing about 12.2% and 12.2% of the total costs for the two samples, respectively, a decrease for the comparison sample amounted to about 150 pounds per acre, representing about 6.5% of its value. For the basic sample, the cost of human work amounted to about 2,920 and 2,780 pounds per acre for both the basic and comparison sample, respectively, representing about 15.5% and 15.8% of the total costs for the two samples, respectively, with a decrease for the comparison sample amounting to about 140 pounds per acre, representing about 4.8% of its value for the basic sample.

While it is clear that the fixed costs, which include rent and incidental expenses, amount to about 9,200 and 9,230 pounds per acre for both the basic and comparison sample, respectively, representing about 49.1% and 52.4% of the total costs for each of them, respectively, with a decrease for the comparison sample amounting to about 30 pounds per acre, representing About 0.3% of its value in the basic sample.

From the above, it is clear that climate changes have negative effects on increasing production costs for the basic sample (early cultivation) compared to the comparison sample (recommended cultivation). This is mainly due to the increase in variable costs represented by increasing the quantities used of production requirements, which includes both increasing the quantities of seeds. Nitrogen and phosphate fertilizers, foliar nutrients, and pesticides to compensate for the weak growth of plants and their stunting due to the negative effects of high temperatures at the beginning of the plant's life, which is the most important stage of the plant's life as it is the foundational stage and the formation of the plant's biomass on which productivity is later built.

3-The impact of climate changes on the most important economic indicators of the wheat crop for the two categories of the study sample according to the difference in planting dates in Dakahlia Governorate for the agricultural season (2022/2023).

By studying the data in Table (12), it is clear that the quantity of the main yield of the wheat crop for both the basic sample (early cultivation) and the comparison sample (recommended cultivation), amounted to about 15.5 and 18.4 ardeb/acre, respectively, with an increase for the comparison sample of about 2.9 ardeb/acre. It represents about 18.7% of its quantity for the basic sample, and by testing the significance of the difference in the productivity of the main product between the two categories of the basic and comparative study using the T-test, its significance was found at a significance level of 1%, while the quantity of the secondary product for the two samples was about 8.4 and 10.5 lambs/acre, respectively, with an increase for the comparison sample. It was about 2.1 lamb/acre, representing about 25% of its quantity for the basic sample. By testing the significance of the difference in secondary product productivity between the basic and comparison study categories using a T-test, its significance was found at a significance level of 1%.

As is clear from the data in Table (12), it was shown that the value of the main wheat crop for both the basic sample (early planting) and the comparison sample (recommended planting) amounted to about 23,250 and 27,600 pounds/acre for the two samples, respectively, with an increase for the comparison sample of about 4,350 pounds, representing about 18.7 pounds. % of its value for the primary sample, and the value of the secondary crop amounted to about 2,184 and 2,730 pounds/acre for the two samples, respectively, with an increase for the comparative sample of about 546 pounds, representing about 25% of its value for the primary sample, and the total yield amounted to about 25,434, 30,330 pounds/acre for the two samples, respectively. An increase in the comparison sample amounted to about 4896 pounds, representing about 19.3% of its value for the basic sample, achieving a net return of about 6639 and 12,760 pounds/acre for the two samples, respectively, with an increase in the comparison sample amounting to about 6121 pounds, representing about 92.2% of its value for the basic sample. It also shows that The cost of producing ardeb amounted to about 1,212,955 pounds/acre for the two samples, respectively, with a decrease for the comparative sample of about 257 pounds, representing about 21.2% of its value for the basic sample, achieving a net return for ardeb that amounted to about 428,694 pounds/acre for the two samples, respectively, with an increase for the comparative sample of about 266 pounds, representing about 62.2% of its value for the basic sample, and the profit of the invested pound amounted to about 0.35 and 0.73 pounds for the two samples, respectively, with an increase for the comparison sample of about 0.38 pounds, representing about 108.6% of its value for the basic sample.

While the margin over variable costs amounted to about 15,869 and 21,960 pounds for the two samples, respectively, with an increase for the comparison sample of about 6,091 pounds, representing about 38.4% of its value for the basic sample, and the percentage of net return to variable costs was about 69.4%, 152.4% for the two samples, respectively. An increase in the comparative sample amounted to about 83.1%, and the ratio of the total return to the total costs amounted to about 135.3% and 172.6%, respectively, an increase in the comparison sample amounted to about 37.3%.

Table (11): Comparative analysis of the impact of climate changes on production cost items for the wheat crop for the two categories of the study sample according to the difference in planting dates in Dakahlia Governorate for the agricultural season (2022/2023).

Items		Planting time (basic category (15/10 - 15/11)	% of the total	Planting time (comparative category15/11 - 15/12)	% of the total	Value change	Rate of change%
Variable costs	Seeds	985	5.2	740	4.2	-245	-24.9
	Nitrogen fertilizer	1800	9.6	1570	8.9	-230	-12.8
	Phosphate fertilizer	400	2.1	320	1.8	-80	-20.0
	Municipal fertilizers	660	3.5	560	3.2	-100	-15.2
	Pesticides and nutrients	500	2.7	250	1.4	-250	-50.0
	The work is automated	2300	12.2	2150	12.2	-150	-6.5
	Workers' wages	2920	15.5	2780	15.8	-140	-4.8
	Total	9565	50.9	8370	47.6	-1195	-12.5
Fixed costs	Winter season rent	9000	47.9	9000	51.2	0	0
	petty cash	230	1.2	200	1.1	-30	-13.1
	Total	9230	49.1	9200	52.4	-30	-0.3
Total costs		18795	100.0	17570	100.0	-1225	-6.5

Source: Collected and calculated from the results of the questionnaire in Dakahlia Governorate for the agricultural season (2022/2023).

Table (12): Comparative analysis of the impact of climate changes on the most important economic indicators: wheat yield for the two categories of the study sample according to the difference in planting dates in Dakahlia Governorate for the agricultural season (2022/2023).

Indicator	Planting time (basic category (15/10 - 15/11)	Planting time (comparative category15/11 - 15/12)	Difference	Rate of change%
Quantity of main production in Ardeb	15.5	18.4	2.9	18.7
The unit price of the main product is in pounds	1500	1500	**0**	**0**
Quantity of secondary production by load	**8.4**	10.5	2.1	25
Unit price of secondary output in pounds	260	260	0	0
The value of the main product in pounds	23250	27600	4350	18.7
The value of the by-product in pounds	2184	2730	546	25
Total return in pounds	25434	30330	4896	19.3
Total costs in pounds	**18795**	**17570**	-1225	-6.5
Net return in pounds	6639	12760	6121	92.2
The cost of producing ardab	1212	955	**-257**	**-21.2**
Net return to ardab	428	694	266	62.2
Earn of the spent pound	0.35	0.73	0.38	**108.6**
Margin over variable costs in pounds	15869	21960	6091	38.4
Net return/variable costs %	69.4 %	152.4 %	83.1 %	119.7
Total Return/Total Cost Ratio %	135.3 %	172.6 %	37.3 %	27.6

Where: profit of the pound spent = (net return / total costs), Margin over variable costs = total revenue - variable costs.

Source: Collected and calculated from the results of the questionnaire in Dakahlia Governorate for the agricultural season **(2022/2023).**

From the above, it is clear that climate changes had a negative impact on early plantings, as the amount of primary and secondary production decreased by about 18.7% and 25%, respectively, which was reflected in a decline in the value of both the primary and secondary yields by the same percentage compared to planting at the time recommended by the Wheat Research Department and The Central Climate Laboratory, and the value of both the total return and the net return decreased by about 19.3% and 92.2%, respectively, compared to planting at the recommended timing. This also affected the increase in the cost of producing ardeb by about 21.2%, a decrease in both the net return of ardeb, and the profit of the invested pound. The margin over variable costs, the ratio of net return to variable costs, and the ratio of total return to total costs are approximately 62.2%, 108.6%, 38.4%, 83.1%, and 37.3% for early crops, respectively.

4-The most important problems facing wheat farmers according to the difference in planting dates for the two categories of the study sample in Dakahlia for the agricultural season (2022/2023).

. Regarding these problems, the relative frequency of the respondents' answers was shown in Table. (13), where the table data indicates that only about 8% of those who prefer early plantings have knowledge of climate changes and their negative effects, while 76% of those who prefer to adhere to planting on the recommended dates expressed their knowledge of the changes. climatic conditions, while about 62% and 20% of the basic sample of early cultivation and the comparison sample acknowledged the existence of a problem of the absence of a quantity of seeds and a weak germination rate, respectively, while about 80% and 16% of the basic sample of early cultivation and the comparison sample acknowledged the existence of a problem of lack The percentage of branching and weak shoots, respectively, and about 66% and 14% of the basic sample of early planting and the comparison sample suffer from the problem of the appearance and spread of many insect and fungal infections, respectively**.**

While about 92% and 8% of the basic sample of early planting and the comparison sample acknowledged the problem of plants entering the stage of expelling ears early, before the appropriate time, respectively, and about 60% and 6% of the basic sample of early planting and the comparison sample acknowledged the problem of the presence of a large percentage of ears. Weak and empty and not fully grown, and about 76% and 6% of the basic sample for early cultivation and the comparison sample acknowledged the problem of the presence of a large percentage of grains that are weak, wrinkled and incompletely mature, while about 86% of the farmers of the basic sample for early cultivation indicated that their productivity was different and lower than the farmers. Of those who planted on the recommended dates, 90% of the comparison sample of those who planted on the recommended dates acknowledged that their productivity differed and increased from the farmers next to them and did not adhere to the recommended planting dates, which in turn was reflected in the fact that only about 20% of the basic sample of those who planted early felt They are satisfied with their productivity, while 84% of the farmers in the comparison sample feel satisfied with their productivity.

From the above, it is clear that the farmers of the basic sample who prefer early planting do not have full knowledge or understanding of the negative effects of climate change. Therefore, they were exposed to many production problems, including poor germination rate, lack of shoots, the spread of many insect and fungal infections, early expulsion of ears, their weakness, and incomplete maturity, which resulted in Due to the small number of grains, their wrinkles and weakness, which was reflected in the lower productivity of the crop compared to farmers who prefer to plant on the recommended dates.

Fourth: Scenarios to predict the impact of climate change and gradual temperature rise on the most important productive and economic indicators of the wheat crop during the period (2023-2030).

In this part of the study, the most important productive and economic indicators for the wheat crop will be predicted during the period (2023-2033), which includes area, productivity, production, imports, the expected economic cost of increasing imports, and the area of land to be reclaimed to compensate for the decrease in productivity and production of the wheat crop expected during that period, assuming that the temperature rises. It is the only factor that reflects the impact of climate changes, assuming that (the price of a ton of wheat imports is about 350 dollars/ton, the cost of reclaiming an acre of new land is about 300 thousand pounds, and the exchange rate to the dollar is about 35 pounds) during the forecast period.

Table (13): Relative frequencies of the most important problems facing wheat farmers according to the difference in planting dates for the two categories of the study sample in Dakahlia Governorate for the agricultural season (2022/2023).

Problems facing wheat farmers	Basic category		Comparativecategory	
	Repetition	%	Repetition	%
Do you know anything about climate change and its negative effects on agriculture	15	%8	146	76%
Absence of a large amount of seeds and weak germination rate	119	62%	38	20%
Low branching rate and general weakness of the vegetative system	154	80%	31	16%
The emergence and spread of many insect and fungal infections	127	66%	27	14%
Plants enter the stage of expelling ears early, before the appropriate time	177	92%	15	8%
A large percentage of ears are weak, empty, and not fully matured	115	60%	12	6%
The presence of a large percentage of weak, wrinkled and incompletely mature grains	146	76%	12	6%
Was there a difference in productivity between you and other farmers?	165	86%	173	90%

Source: Collected and calculated from the results of the questionnaire in Dakahlia Governorate for the agricultural season (2022/2023).

Accordingly, three expected scenarios were formulated, as shown in Table (14). The first scenario assumes that temperatures will not change, while the second scenario assumes that a gradual increase in temperatures by one degree Celsius will lead to a gradual decrease in productivity by 6% during the forecast period, while the scenario assumes Third, a gradual increase in temperatures by two degrees Celsius will lead to a gradual decrease in productivity by 12% during the forecast period. The following are the most important results and hypotheses of the scenarios:

A- The first scenario: It is assumed that temperatures do not change and climate conditions remain stable during the forecast period (2023-2033) Table (14). The results of this scenario are as follows:

1-The cultivated area of wheat is expected to increase from about 3.55 million acres in 2023 to about 3.99 million acres in 2033, an increase of 0.44 million acres, representing about 12.4% of the crop area in 2023.

2-It is also expected that wheat crop productivity will increase from about 2.79 tons in 2023 to 2.84 tons in 2033, an increase of 0.05 tons, representing about 1.8% of the crop's productivity in 2023.

3- This will result in an increase in wheat crop production from about 9.87 million tons in 2023 to about 11.23 million tons in 2033, an increase of 1.36 million tons, representing about 13.8% of wheat crop production in 2023.

4- It is also expected that wheat imports will increase from about 12.82 million tons in 2023 to about 16.93 million tons, an increase of 4.11 million tons, representing about 32.1% of wheat imports in 2023.

B- The second scenario:

Assuming the temperature rises by one degree Celsius gradually, by an estimated rate of about 0.091 degrees Celsius every year, it will lead to a gradual decrease in productivity by 6%, that is, by an estimated rate of 0.55% every year during the forecast period (2023-2033) Table (14) the results of this scenario are as follows:

1-It is expected that wheat productivity will decrease from about 2,774 tons in 2023 to about 2,669 tons in 2033, a decrease of about 0.105 tons, representing about 3.78% of the crop's productivity in 2023.

Table (14): Expected scenarios for wheat production and imports as a result of rising temperatures during the period (2023/2033).

Statement / Years	Estimated area(1) thousand acres	(2) Estimated productivity tons/acre	(3) Estimated production, one thousand tons	Estimated imports One thousand tons(4)	Second scenario (5)	Third scenario (6)	Productivity after scenario 2, (7)={2-(2*5)}	Productivity after scenario3, (8) ={2-(2*6)}	Production after scenario2, (9)=(1*7)	Production after scenario3, (10)=(1*8)
2023	3550	2.79	9873	12824	0.55%	1.09%	2.774	2.759	9848	9794
2024	3594	2.79	10009	13234	**1.09%**	2.18%	2.759	2.729	9916	9808
2025	3639	2.80	10144	13644	1.64%	3.27%	2.754	2.708	10022	9854
2026	3683	2.80	10280	14055	2.18%	4.36%	2.738	2.687	10084	9896
2027	3727	2.81	10415	14465	2.73%	5.45%	2.733	2.656	10186	9899
2028	3771	2.81	10551	14876	3.27%	6.54%	2.718	2.626	10250	9903
2029	3816	2.82	10686	15286	3.82%	7.63%	2.712	2.604	10349	9937
2030	3860	2.82	10822	15696	4.36%	8.72%	2.697	2.574	10410	9936
2031	3904	2.83	10957	16107	4.91%	9.81%	2.691	2.552	10506	9963
2032	3948	2.83	11093	16517	5.45%	10.90%	2.675	2.521	10561	9953
2033	3992	2.84	11228	16928	6.00%	12.00%	2.669	2.499	10655	9976

Source: Collected and calculated from Tables (1 and 3) of the study.

2-It is expected that wheat production will decrease from about 9.873 million tons to about 9.848 million tons in 2023, amounting to a decrease of about 25 thousand tons. In order to compensate for this decrease in production, the reclamation of a land area of about 9 thousand acres is required, the cost of which is estimated at about 2.74 billion pounds, while a decrease is expected. Production from about 11.228 million tons to about 10.655 million tons in 2033, with a decrease of about 573 thousand tons. In order to compensate for this decrease in production, the reclamation of a land area of about 215 thousand acres is required, the cost of which is estimated at about 64.45 billion pounds, assuming the cost of land reclamation remains constant during the forecast period.

3-It is also expected that the amount of wheat imports will increase from about 12.85 million tons, with an estimated import value of about 4.5 billion dollars in 2023, to about 17.5 million tons, with an estimated import value of about 6.2 billion dollars in 2033, assuming the import price of a ton of wheat remains constant during the forecast period.

- From the above, it is clear that the expected decrease in wheat crop production as a result of a gradual increase in temperature by one degree Celsius during the forecast period is estimated at about 25 thousand tons in 2023, and the decrease in production will be compensated for by reclaiming a land area of about 9 thousand acres, the cost of reclamation of which is estimated at about 2.74. One billion pounds, equivalent to about 78.3 million dollars, or through importing an amount of wheat estimated at about 8.7 million dollars, while the decline in wheat production in 2033 is expected to amount to about 573 thousand tons. This decrease will be compensated for through the reclamation of lands of about 215 thousand acres, the cost of reclamation of which is estimated at about 64.45. One billion pounds, equivalent to about 1.84 billion dollars, or through imports to compensate for this shortfall in production by about 200.5 million dollars, assuming the stability of the exchange rate and the import price of a ton of wheat during the forecast period, (follow-up table14).

Table (follow-up table14): Expected scenarios for the expected economic cost of decreased production and increased imports as a result of climate changes during (2023-2033).

Statement / Years	Amount of production difference after Scenario 2, (11) = (3-9)	Amount of production difference after Scenario3, (12) = (3-10)	The area reclaimed to compensate for the lack of production after scenario 2 is achieved = (11)/(7)		The area reclaimed to compensate for the lack of production after scenario 3 is achieved = (12)/(8)		Imports to compensate for the lack of production after scenario 2 is achieved= (4+11)		Imports to compensate for the lack of production after scenario 3 is achieved = (4 +12)	
			Area (13)	Cost = (13) *Cost of reclaiming an acre	Area (14)	Cost = (14) *Cost of reclaiming an acre	Quantity (15)	) Value = (15) * Import price per ton in dollars	Quantity (16)	) Value = (16) * Import price per ton in dollars
2023	25	79	9	2736	28	8541	12849	4497255	12903	4515893
2024	93	201	34	10129	74	22093	13327	4664504	13435	4702241
2025	122	290	44	13311	107	32081	13766	4818168	13934	4876756
2026	196	384	72	21470	143	42848	14251	4987831	14439	5053573
2027	229	516	84	25149	194	58293	14694	5142938	14981	5243381
2028	301	648	111	33270	247	74069	15177	5312098	15524	5433524
2029	337	749	124	37280	288	86306	15623	5468053	16035	5612298
2030	412	886	153	45782	344	103305	16108	5637653	16582	5803826
2031	451	994	168	50316	389	116849	16558	5795418	17101	5985347
2032	532	1140	199	59675	452	135671	17049	5967185	17657	6179982
2033	573	1252	215	64446	501	150299	17501	6125473	18180	6362997

Where: The average cost of reclaiming an acre is estimated at about 300 thousand pounds, the average price of importing a ton of wheat is estimated at about 350 dollars.
Source: Collected and calculated from Tables (1 and 14) of the study.

Table (follow-up table14):
Expected scenarios for the expected economic cost of decreased production and increased imports as a result of climate changes during (2023-2033).
Where: The average cost of reclaiming an acre is estimated at about 300 thousand pounds, the average price of importing a ton of wheat is estimated at about 350 dollars.
Source: Collected and calculated from Tables (1 and 14) of the study.

C- The third scenario:
Assuming a gradual increase in temperature by two degrees Celsius, by an estimated 0.18 degrees Celsius every year, it will lead to a gradual decrease in productivity by 12%, or by an estimated 1.09% every year during the forecast period (2023-2033). Table (14) is represented by the results of this scenario are as follows:
1- It is expected that wheat crop productivity will decrease from about 2,759 tons in 2023 to about 2,499 tons in 2033, a decrease of about 0.26 tons, representing about 9.42% of wheat productivity in 2023.

2-Wheat production will decrease from about 9.873 million tons to about 9.794 million tons in 2023, amounting to a decrease of about 79 thousand tons. To compensate for this decrease in crop production, the reclamation of a land area of about 28 thousand acres is required, the cost of which is estimated at about 8.5 billion pounds, while production from wheat is expected to decrease. Wheat is about 11.228 million tons to about 9.976 million tons in 2033, a decrease of about 1.252 million tons. To compensate for this decrease in wheat production, the reclamation of a land area of about 501 thousand acres is required, the cost of which is estimated at about 150.3 billion pounds, assuming the cost of land reclamation remains constant during the forecast period.

3-Also, the amount of wheat imports will increase from about 12.903 million tons, with an estimated import value of about 4.52 billion dollars in 2023, to about 18.18 million tons, with an estimated import value of about 6.4 billion dollars in 2033, assuming the import price of a ton of wheat remains constant during the forecast period.

- From the above, it is clear that the amount of decrease in wheat crop production as a result of a gradual rise in temperature by two degrees Celsius during the forecast period is estimated at about 79 thousand tons in 2023, and the decrease in production will be compensated for by reclaiming a land area of about 28 thousand acres, the cost of reclamation of which is estimated at about 8.5 billion pounds, including It is equivalent to about 243 million dollars, or through importing the crop at about 27.7 million dollars, while a decrease in wheat production in 2033 is expected to amount to about 1.25 million tons. This decrease will be compensated for by reclaiming lands of about 501 thousand acres, the cost of which is estimated at about 150.3 billion pounds, equivalent to About 4.3 billion dollars, or through importing this production shortfall of about 437.5 million dollars, assuming the stability of the exchange rate and the stability of the import price of a ton of wheat during the forecast period (follow-up table14).

Recommendations:
1-Working to increase the wheat crop area annually by increasing reclaimed lands and cultivating them with wheat crops in order to avoid a decrease in production with possible climate fluctuations and changes.
2-The need for research centres to work on finding wheat varieties that can withstand one or two degrees of high temperature and have higher productivity, while making them available to agricultural directorates and agricultural cooperative societies at subsidized prices to encourage their dissemination among farmers.

3-Establishing storage silos for the crop near the new growing areas for storage for longer periods.
4-Spreading agricultural awareness of strategic crops, the most important of which is the wheat crop, among farmers with recommendations and recommended dates for planting through all methods of communication, such as direct and indirect agricultural extension and various media channels.

References:

[1]. Agricultural Administration of Belqas and Mansoura Centres in Dakahlia Governorate “unpublished data"
[2]. Central Agency for Public Mobilization and Statistics, Annual Statistical Bulletin (Geography and Nature), Foreign Trade Bulletin, various years.
[3]. Climate Change Document “Climate Changes, General Background and Future Directions” Conference of the Parties No. 27 (COP27) in Sharm El-Sheikh - Egypt 2022.
[4]. Directorate of Agriculture in Dakahlia Information Centre (monthly climate data for Dakahlia Governorate).
[5]. Mahmoud Mohamed Fawaz (Doctor), “An economic study of climate change and its effects on sustainable development in Egypt,” Egyptian Journal of Agricultural Economics, Volume Twenty-Five, Issue Three, September 2015.
[6]. Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletin and Food Balance Bulletin, various years.
[7]. Mohamed Noman Nofal, (Doctor), “The impact of climate change on the production of grain crops in Egypt,” Egyptian Journal of Agricultural Economics, Volume Nineteen, Issue Three, September 2009.

[8]. Steven. K. Thompson, 2012.sampling, third edition, p:59-60.
[9]. The Central Agency for Public Mobilization and Statistics, “The impact of climate changes on strategic crops in Egypt during the period (2015-2022)”, January 2017.

3/20/2024