Zagazig J. Agric. Res., Vol. 51 No. (6) 2024 2171-2188

Agricultural Economics and Social Science

Available online at http://zjar.journals.ekb.eg

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

THE SOCIO-ECONOMIC IMPACT OF ENVIRONMENTAL AWARENESS OF CLIMATE CHANGE ON THE PRODUCTIVITY OF SOME AGRICULTURAL CROPS IN EGYPT: A CASE STUDY OF QALYUBIA GOVERNORATE

Fatma A.M. ElBateh[1*], Rabab S.A. Mohammed[2] and M.M. Elhabbaq[1]

1. Agric. Econ. Branch, Agric. Econ. Dep., Fac. Agric., Benha Univ., Egypt

2. Agric. Ext. Branch, Agric. Econ. Dep., Fac. Agric., Benha Univ., Egypt

Received: 06/11/2024; Accepted: 11/11/2024

ABSTRACT: This study investigates the economic and social impacts of climate change on agricultural production, focusing on various crops such as maize, rice, and soybean in Qalyubia Governorate. The statistical analysis technique will be performed under a descriptive-analytical methodology in order to focus on the influence that climatic factors have on crop productivity. The results depicted that from the findings, there is an increase in the concentrations of greenhouse gases and a rise in temperature, whereas relative humidity and rainfall were on a decline. These have caused marked changes in the cultivated areas, production, and productivity of the studied crops. It has also been observed that maize and rice showed significant declines in productivity and thus faced immense economic losses. The study also covers the degree of environment awareness on the part of farmers, revealing that farmers have a low to moderate degree of awareness regarding climate change. Another result points out that rice farmers express a significantly higher level of environmental awareness than maize and soybean farmers. Results from this study highlight the urgent need to increase environmental awareness and the adoption of sustainable agricultural methods in order to reduce the impacts of climate change on agricultural production. This, therefore, calls for very specific extension programs, education, and outreach on adapting to and mitigating the impacts of climate change among farmers. This present study also established that policies and interventions are needed in support of farmers to deal with the implications of climate change for food security in Egypt.

Key words: Socioeconomic impact, climate change, awareness, agricultural productivity, Qalyubia Governorate

INTRODUCTION

Currently, climate change is one of the most dramatic challenges facing humanity, while its influence is very strong in many sectors, especially agriculture. Since agriculture is the backbone of many developing economies like Egypt, this economy happens to be very vulnerable to climatic changes. the fluctuation in temperature and precipitation led to reduce in crop productivity, hence affecting food security and the livelihood of the farmers according, Egypt's arid and semi-arid climate with low rainfall, it makes highly disastrous impacts of climate change. Especially heatwaves, the process of drought, and desertification. In 2021, the climate crisis led to decrease in mango and olive production about 40% and 80% respectively. Serious fall in the production of strategic crops like soybeans, Maize, and rice is expected by 2050 due to the expected-climatic changes. (**Public Policy Forum, the American University in Cairo, 2022**).

Climate change, according to the Intergovernmental Panel on Climate Change, is defined as a change in the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for

* **Corresponding author: Tel. :**+ 201095235652

E-mail address: mmhabbaq@fagr.bu.edu.eg

an extended period, typically decades or longer. These changes might, be attributable to natural variability and human activities (IPCC, 2022). The effects of climate change in agriculture are manifested through increased temperature, increased evaporation, altered precipitation patterns, increased sea levels, and an increased intensity and frequency of extreme weather conditions or events as in the form of droughts and floods. which led to give rise to land degradation, soil salination, increased pest and disease incidences, and a reduction in yields of major crops like wheat, rice, and cotton. By the aggravating factors of climate change, environmental awareness has become of vital importance with regard to mitigating negative consequences.

Environmental awareness is defined as "an individual's or society's perception of the relationship between human activities and the environment, and an understanding of the impacts of these activities on the environment and society (**Darity, 2008**). It would mean complete understanding of the causes and effects of climate change, including recognition of roles that individuals, communities, and institutions may play in mitigation and adaptation to those impacts.

Research Problem

Recent climatic changes have led to a significant decline in the productivity of many essential strategic crops such as wheat, rice, and maize. It is expected that the production of certain strategic crops will decrease substantially by 10-30% by 2050 (**IPCC, 2022**).

Research Objectives

This research is mainly focused on study and analyze the various economic and social impacts of climate change on agricultural production as follow:

- Identifying the issue of climate change and studying its effects through changes in temperature and rainfall rates on agricultural production.
- Measuring the impact of climate change on productivity per feddan and total production of the main food crops under study.
- Quantifying the economic effects of differences in average crop production resulting from variations in the climatic regions where they are cultivated.
- Measuring the economic effects of differences in average production for the study crops within the research sample.
- Constructing a scale to measure environmental awareness of climate change in the study villages.
- Assessing the level of environmental awareness of climate change in the study villages.
- Determining the differences between farmers in terms of their level of environmental awareness of climate change based on the study village and the crop cultivated.

Research Methodology

This study has adopted a descriptive-analytical approach complemented by the statistical analysis technique-simple regression and multiple regression analysis during the period 2000-2023- to analyze the impact of climatic factors on the productivity of maize, rice, and soybean. The analysis included numerous independent variables expected to influence the productivity of these crops.

The study relied primarily on data collection and recording using a measurement scale designed specifically for this research. The researcher developed a scale to measure environmental awareness of climate change. According the study's objectives, the following statistical tests were estimated as follow:

a) Pearson's correlation coefficient to determine the strength of the correlation between the dimensions of the scale.

b) Cronbach's alpha coefficient to measure the scale's reliability.

c) The t-test to measure the differences in environmental awareness between farmers in Mit Kennana village (Toukh Center) and Marsafa village (Benha Center).

A scale to measure environmental awareness of climate change was designed by the following stages:

Validating the scale

The researcher has used two ways to measure the validity of the scale:

Facial validity

The scale was shared with five experts in the field and, on the basis of their suggestions, modifications were made, rephrasing ambiguous statements, deleting items irrelevant or redundant, and adding items wherever necessary. Items with less than 90% agreement by experts were deleted.

Internal consistency

Pearson's correlation coefficient was computed between the score of each item and the total score of the scale. Most of the correlation coefficients were high and statistically significant at 0.01 level and ranged from 81% to 26%.

Reliability

The Cronbach's alpha test was used for the reliability of the scale. 0.958 means that the scale is reliable and appropriate for use.

Data Sources

The required data for the study was collected from primary and secondary sources.

a) Secondary data included the published and unpublished records of the Central Laboratory for Climate Information, the Agricultural Meteorological Department of the Central Administration for Agricultural Guidance, and the Ministry of Agriculture and Land Reclamation. The forecasted data was retrieved estimated from the Egyptian Agricultural Development Strategy 2030, while the published data was accessed through the international information network.

b) Primary data were collected by field survey using a specially designed questionnaire. Sample was selected from Qalyubiya Governorate due to its significance in the agricultural sector. Due to the large area of the governorate, the two largest agricultural centers in terms of the number of farmers were chosen: Toukh Center that included about 71,230 farmers, and Benha Center that included about 50,160 farmers. Mit Kenana village (belonging to Toukh Center) that included about 4,971 farmers, and Marsafa village (belonging to Benha Center) that included about 3,430 farmers.

Whereas a systematic random sample of 2% of the total population was taken, and the sample size included about 169 respondents divided into: 100 from Mit Kenana and 69 from Marsafa. Data collection was carried out using a self-designed questionnaire prepared by the researcher, which had previously revised and confirmed expert validation. The data was obtained through direct personal interviews during May and June 2024.

Research Findings

Annual average concentration of major greenhouse gases in the earth's atmosphere

As is shown, from data in Table 1, there is a clearly increasing trend in the concentration of CO2, CH_4, and N_2O gases within the Earth's atmosphere during the study period. The period divided into four periods to analyze trends and variability in greenhouse gas concentrations over specific time frames. By breaking down the data into five-year intervals. These increases are majorly related to human activities which have involved the burning of fossil fuels for energy and industrial processes. Carbon Dioxide (CO_2): From approximately 315.5 ppm in the previous period, the average concentration of CO_2 rose to 331.1 ppm, which represents a 5.079% increase.

Methane (CH4)

Methane concentrations have increased dramatically as well, from 1782 ppb to 1871 ppb-a 4.99% increase.

Nitrous Oxide (N_2O)

The growth rate of nitrous oxide was the highest of the three gases, having concentrations rise from 369.6 ppb to 408.1 ppb. This represents a 10.41% increase.

This rise in the measured concentrations of these greenhouse gases indeed shows a marked variation in the composition of the Earth's atmosphere. While all three gases were on an upward trend, their growth rates varied between 0.69% and 2.53%, and among those, the nitrous oxide increment was the most prominent. The Main reason of this uptrend is burning-related processes emitting these gases into the atmosphere.

Table 1. Annual Average Concentration of Major Greenhouse Gases in the Earth's Atmosphere, 1998-2023

Period	CO_2 (PPM)	CH_4 (PPb)	N_2O (PPb)
1998-2002	315.5	1782	369.62
2003-2007	319.2	1788.6	379.42
2008-2012	321.7	1800	385.4
2013-2017	326.2	1827	396
2018-2023	331.1	1871	408.1
Mean	322.7	1813.7	387.7
Standard Deviation (SD)	6.08	36.34	14.88
Coefficient of Variation (CV)	1.88%	2.00%	3.84%
Annual Growth Rate	1.21%	0.69%	2.53%

Source: World Data Center for Greenhouses Gases (WDCGG)

Evolution of key climatic variables during the study period

Carbon dioxide CO_2 emissions

Data in Table 2 indicated the increasing temporal development of carbon dioxide emissions in Egypt during the period 2000-2023 with an annual average estimated at about 171.3 million metric tons of carbon dioxide equivalent. Emissions ranged between a minimum of 114.61 million metric tons in 2000 and a maximum of 209.96 million metric tons in 2017, an increase of about 83.2%. The estimated time trend equation in Table 3 for the Carbon Dioxide Emissions shows that there is an increase in a statistically significant upward trend of about 4.88 million metric tons per year, which is equivalent to about 2.85% of the average value during the study period.

Maximum temperature

The maximum temperature increased quite regularly with an average temperature estimated at about 30.85°C during the study period, ranging from a minimum of 26.6°C in 2000 to a maximum of 43.4°C in 2021, representing an increase of 63.2%. The estimated time trend equation for the maximum temperature shows that there is an increase in a statistically significant upward trend of about 0.460°C per year, which is equivalent to about 1.49% of the average value during the study period.

Minimum temperature

The minimum temperature increased quite regularly with an average temperature estimated at about 18.45°C during the study period, ranging from a minimum of 14.5°C in 2000 to a maximum of 33.6°C in 2022, representing an increase of 131.72%. The estimated time trend equation for the minimum temperature shows that there is an increase in a statistically significant upward trend of about 0.515°C per year, which is equivalent to about 2.79% of the average value during the study period.

Relative humidity

The relative humidity decreased quite regularly with an average relative humidity estimated at about 52.42% during the study period, ranging from a minimum of 42.2% in 2017 to a maximum of 56.3% in 2022. The estimated time trend equation for the relative humidity shows that there is an decrease in a statistically significant downward trend of about 0.239% per year, which is equivalent to about 0.46% of the average value during the study period.

Table 2. Average maximum and minimum actual temperatures, humidity, and rainfall in Egypt during the study period

Year	Carbon Emissions (MMT)	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)	Rainfall amount (mm)
2000	114.61	26.6	14.5	55.4	3.92
2001	116.12	28.4	15.4	53.8	3.83
2002	117.25	28.4	15.4	55.6	3.45
2003	118.31	28.4	15.4	56	3.45
2004	123.26	28.5	15.5	55.9	3.49
2005	130.34	28.5	15.4	55.7	3.49
2006	139.11	28.6	15.6	55.1	3.49
2007	147.68	29.3	15.6	54.4	3.99
2008	155.04	28.4	15.7	55.8	4.18
2009	162.71	29.4	16.9	50.2	4.19
2010	174.60	30.3	17.9	49.4	1.50
2011	181.95	30.3	17.9	51.8	1.55
2012	187.73	27.8	16.7	55.4	2.16
2013	196.90	27.8	16.7	53.3	4.70
2014	197.14	30.6	16.7	50.4	4.70
2015	201.34	31	19.5	47.4	4.09
2016	206.20	29	16.8	52.6	1.35
2017	209.96	30.2	17.9	42.2	3.53
2018	206.75	29.4	17.2	43	2.85
2019	199.90	30.2	18.4	47.2	1.42
2020	201.97	30.3	18.4	52.4	3.13
2021	204.74	43.4	30	54.4	2.62
2022	208.01	43	33.6	56.3	1.3
2023	209.6	42.6	29.7	54.4	1.3
Mean	171.30	30.85	18.45	52.421	3.07

Source: Central Agency for Public Mobilization and Statistics, Environment Publications, Various Issues.

Table 3. Time trend equations for maximum and minimum temperatures, relative humidity, and rainfall in Egypt during the study period (2000 – 2023)

Equation Number	Dependent Variable	Equation	Mean	R-squared	F-statistic	Rate of Change%
1	**Carbon Emissions (MMT)**	$Y_t = 110.34 + 4.88\ X_t$ (14.57)**	171.3	0.91	212.30	2.85
2	**Maximum Temperatures**	$Y_t = 25.098 + 0.460\ X_t$ (4.31)**	30.85	0.46	18.57	1.49
3	**Minimum Temperatures**	$Y_t = 12.015 + 0.515\ X_t$ (4.83)**	18.45	0.51	23.28	2.79
4	**Relative Humidity**	$Y_t = 55.413 - 0.239\ X_t$ (-2.16)*	52.42	0.18	4.68	-0.46
5	**Rainfall**	$Y_t = 4.076 - 0.081\ X_t$ (-2.71)*	3.07	0.25	7.33	-2.62

Where: Y_t = predicted value of the dependent variable
X_t = time variable, where t = 1, 2, 3, ..., 24
** Significant at the 0.01 level * Significant at the 0.05 level
( ) Numbers in parentheses below the regression coefficient refer to the t-statistic
Source: Calculated from the data in Table 2.

The production status of the study crops

Table 4 showed the cultivated area, production, productivity, and net returns of the study crops-Maize, rice, and soybeans-during the period 2000 -2022.

The average cultivated area of Maize was 1,996,600 feddans during the study period, with a maximum value of 2,341,000 feddans in 2018 and a minimum value of 1,658,000 feddans in 2003. A time trend analysis revealed a significant positive trend in the cultivated area of Maize at a rate of 31,960 feddans per year, representing a 1.6% annual increase. Approximately 81% of the variations in the cultivated area were explained by the time trend.

The average Productivity of Maize was 3.35 tons per feddan, with a maximum of 3.6 tons per feddan in 2006 and a minimum of 3.1 tons per feddan in 2016. However, the time trend analysis showed a significant negative trend in productivity, decreasing at a rate of 0.011 tons per year, or 0.32% annually. About 39% of the variations in productivity were attributed to the time trend.

Total Maize production averaged 6,664,700 tons, with a maximum of 7,700,000 tons in 2016 and a minimum of 5,650,000 tons in 2000. The average net return was approximately 2,153,300 LE. The time trend analysis indicated a significant positive trend in net returns, increasing at a rate of 88,220 L.E per year, or 4.09% annually. Approximately 52% of the variations in net returns were explained by the time trend

The average cultivated area of rice in Egypt during the specified period was approximately 1,378 thousand feddans, with a maximum of 1,770 thousand feddans in 2008 and a minimum of 859 thousand feddans in 2018. A time trend analysis revealed a significant annual decline of approximately 20.56 thousand feddans (or 1.49% of the mean) in the cultivated area. The coefficient of determination (R^2) indicated that approximately 44% of the variations in the cultivated area could be attributed to factors represented by the time trend.

Concurrently, the average rice productivity was about 3.96 tons per feddan, with a high of 4.23 tons per feddan in 2006 and a low of 3.64 tons per feddan in 2018. This time trend analysis gave the annual decline at about 0.012 tons or 0.32% of the mean. The R^2 value suggested that about 32% of the variations in productivity could be accounted for by the time factor.

Despite this, in the decreasing trends for both cultivated area and productivity, total rice production had an average of 5,467.91 thousand tons, with the maximum of 7,238 thousand tons in the year 2008 and the minimum of 3,122 thousand tons in the year 2018. Notably, the net farm income from rice cultivation exhibited a significant annual increase of approximately 137.6 thousand L.E (or 5.01% of the mean), as indicated by the time trend analysis. The R^2 value suggested that approximately 64% of the variations in net farm income could be attributed to time-related factors.

The average cultivated area of soybeans during the study period was approximately 27,110 feddans, with a maximum of 85,900 feddans in 2022 and a minimum of 9,200 feddans in 2000. Time trend analysis indicated a significant upward trend in soybean cultivation at a rate of 1,670 feddans per year, representing a 6.17% annual increase over the mean. Where, about 51% of the variation in cultivated area could be contributed by the time factor.

Productivity was about 1.32 tons per feddan, while maximum about 1.55 tons per feddan in a year 2009 and minimum 1.14 ton per feddan in a year 2000. Time trend analysis of productivity shows a positive trend; however, it is insignificant.

The average soybean produced was 32,650 tons, which ranged from a high of 62,580 tons in the year 2022 to a low of 10,520 tons in the year 2000. The trend of the net farm income for soybean cultivation as inferred was an increasing one, with an average annual increase amounting to 144,570 L.E, reflecting a growth rate of 8.76 percent per year about the mean. This indicates that, as per the result, about 43 percent variation in the net farm income could be explained by time.

Quantitative estimation of the impact of climatic factors on the productivity of the studied crops

Multiple regression analysis was done in this section for the period 2000-2022 to study the effect of climatic factors on the production of

Table 4. Evolution of key economic indicators for the study crops in Egypt, 2000-2022

Year	Maize				Rice				Soybeans			
	Area (thousands of feddans)	Productivity (tons per feddan)	Production (thousands of tons)	Net return (thousands of L.E)	Area (thousands of feddans)	Productivity (tons per feddan)	Production (thousands of tons)	Net return (thousands of L.E)	Area (thousands of feddans)	Productivity (tons per feddan)	Production (thousands of tons)	Net return (thousands of L.E)
2000	1679	3.36	5650	763	1570	3.82	5997	615.3	9.20	1.14	10.52	-244.5
2001	1773	3.43	6094	752	1341	3.9	5228	709.3	12.69	1.17	14.89	-205.3
2002	1668	3.40	5682	824	1548	3.94	6098	983	14	1.26	17.69	180
2003	1658	3.43	5683	856	1509	4.09	6170	2113	19.74	1.45	28.68	1070
2004	1685	3.47	5840	1935	1527	4.13	6308	1969	34.15	1.27	43.43	908
2005	1940	3.54	6867	1821	1460	4.20	6130	2149	20.08	1.29	25.82	798
2006	1708	3.60	6150	1881	1593	4.23	6738	2030	17.79	1.29	23.02	698
2007	1782	3.45	6141	3051	1673	4.01	6708	2682	18.54	1.38	25.61	952
2008	1860	3.39	6306	1753	1770	4.09	7238	2259	20.67	1.41	29.17	989
2009	1978	3.36	6644	1611	1369	4.03	5518	1458	17.05	1.55	26.40	1372
2010	1998	3.14	6276	2430	1093	3.96	4327	3430	19.90	1.20	30.78	681
2011	1759	3.35	5886	2658	1409	4.02	5664	3832	22.72	1.31	29.77	1447
2012	2157	3.34	7206	3220	1472	4.01	5903	3620	17.11	1.52	25.94	3878
2013	2139	3.32	7102	3038	1419	4.03	5719	3581	22.42	1.46	32.75	3570
2014	2186	3.32	7245	2921	1364	4	5461	3364	27.87	1.40	39.86	3273
2015	2261	3.32	7255	2234	1216	3.96	4818	2948	33.90	1.37	46.67	2976
2016	2213	3.12	7700	1629	1458	4.03	5877	2391	32.05	1.41	45.14	1574
2017	2304	3.24	7414	2049	1307	3.79	4958	5221	30.40	1.25	35.06	1216
2018	2341	3.33	7022	1957	859	3.64	3122	2758	30.55	1.23	38.31	550
2019	2153	3.18	7121	2903	1304	3.83	4798	3759	38.19	1.23	46.77	695
2020	2154	3.24	7134	3285	1188	3.74	4440	3275	29.45	1.20	36.16	2102
2021	2251	3.33	7411	2977	1105	3.84	4242	3997	49.05	1.28	36.02	3962
2022	2275	3.31	7460	2978	1140	3.74	4300	4067.3	85.9	1.32	62.58	5520
Mean	**1996.61**	**3.35**	**6664.74**	**2153.30**	**1378.00**	**3.96**	**5467.91**	**2748.30**	**27.11**	**1.32**	**32.65**	**1650.49**

Source:

- Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Department of Agricultural Economics, Agricultural Statistics Bulletin, various issues

- Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Bulletin of Cost Statistics and Net Returns, various issues.

Table 5. Analysis of productivity trends for maize, rice, and soybean crops in Egypt, 2000-2022

Equation Number	Crop	Dependent Variable	Equation	Mean	R-squared	F-statistic	Rate of Change %
1	Maize	**Area (thousands of feddans)**	Y_t= 1613.1+ 31.96 X_t (9.36)**	1996.61	0.81	87.57	1.6
2	Maize	**productivity (tons per feddan)**	Y_t= 3.47- 0.011Xt (-3.66)**	3.35	0.39	13.37	-0.318
3	Maize	**Net return (thousands of L.E)**	Y_t= 1094.6+ 88.22Xt (4.75)**	2153.30	0.52	22.55	4.09
4	Rice	**Area (thousands of feddans)**	Y_t= 1624.7 - 20.56 Xt (-4.06)**	1378.00	0.44	16.48	-1.49
5	Rice	**productivity (tons per feddan)**	Y_t= 4.11- 0.012 Xt (-3.12)**	3.96	0.32	9.73	-0.316
6	Rice	**Net return (thousands of L.E)**	Y_t= 1097.5+ 137.6X_t (6.09)**	2748.3	0.64	37.18	5.01
7	Soybeans	**Area (thousands of feddans)**	Y_t= 7.03 + 1.67X_t (4.71)**	27.11	0.51	22.21	6.17
8	Soybeans	**productivity (tons per feddan)**	Y_t= 1.31+ 0.0009X_t (0.25)$^-$	1.32	0.003	0.066	0.06
9	Soybeans	**Net return (thousands of L.E)**	Y_t= -84.33 + 144.57X_t (3.95)**	1650.49	0.43	15.62	8.76

Where: Y_t = predicted value of the dependent variable

X_t = time variable, where t = 1, 2, 3, ..., 23

** Significant at the 0.01 level, * Significant at the 0.05 level - insignificant

( ) Numbers in parentheses below the regression coefficient refer to the t-statistic

Source: Calculated from the data in Table 4.

Maize, rice, and soybean crops. For this analysis, several variables used are independent affect the productivity of these crops by the following equation:

$$Y_t = f(X_1, X_2, X_3, X_4)$$

Where:

Y is the productivity

X_1 represents the maximum temperature during the period 2000-2022

X_2 represents the minimum temperature during the period 2000-2022

X_3 represents the relative humidity during the period 2000-2022

X_4 represents quantity of rainfall during the period 2000-2022

** ،* denote significance at 0.01, 0.05, and insignificant levels, respectively.

Maize

A multiple linear regression model in double logarithmic form was estimated to investigate the relationship between productivity per feddan of Maize (as the dependent variable) and climatic factors (as independent variables) over the period 2000-2022. The results are as follows:

$$\ln Y_t = 0.0712 + 0.261 \ln X_1 - 0.165 \ln X_2 + 0.172 \ln X_3 + 0.036 \ln X_4$$
$$(1.64)^{*} \quad (-1.34)^{-} \quad (2.64)^{*} \quad (2.51)^{*}$$
$$R^2 = 0.57 \qquad F = 6.34^{**}$$

The R-squared value of 0.57 indicates that approximately 57% of the variation in Maize productivity can be explained by the included climatic factors. The F-statistic was about 6.34, showed that the overall model is statistically significant.

The regression results show that there is statistically significant relationship between Maize productivity and maximum temperature. This implies that a 1% increase in maximum temperature leads to a 0.261% increase in Maize productivity.

There is statistically insignificant relationship between Maize productivity and minimum temperature. This implies that a 1% increase in minimum temperature leads to a 0.165% decrease in Maize productivity.

The regression results show that there is statistically significant relationship between Maize productivity and humidity. This implies that a 1% increase in humidity leads to a 0.172% increase in Maize productivity.

The regression results show that there is statistically significant relationship between Maize productivity and rainfall. This implies that a 1% increase in rainfall leads to a 0.036% increase in Maize productivity.

Rice

A double log multiple regression analysis was conducted to determine the impact of various climatic variables on rice productivity in the period 2000-2022. The F-statistic was statistically significant at $p<0.05$ in the model, with an adjusted R-square of 0.52, thus indicating that a large portion of variation in rice productivity was explained by the different climatic factors that featured in this model.

$$\ln Yt = 0.714 + 0.08 \ln X1 - 0.151 \ln X2 + 0.21 \ln X3 + 0.002 \ln X4$$

$$(0.32)^{-} \quad (-0.96)^{-} \quad (2.494)^{*} \quad (0.13)^{-}$$

$$R^2 = 0.52 \qquad F = 5.09^{**}$$

The R-squared value of 0.52 indicates that approximately 52% of the variation in rice productivity can be explained by the included climatic factors. The F-statistic was about 5.09, showed that the overall model is statistically significant.

The regression results show that there is statistically insignificant relationship between rice productivity and maximum temperature. This implies that a 1% increase in maximum temperature leads to a 0.08% increase in rice productivity.

There is statistically insignificant relationship between rice productivity and minimum temperature. This implies that a 1% increase in minimum temperature leads to a 0.151% decrease in rice productivity.

The regression results show that there is statistically significant relationship between rice productivity and humidity. This implies that a 1% increase in humidity leads to a 0.21% increase in rice productivity.

The regression results show that there is statistically insignificant relationship between rice productivity and rainfall. This implies that a 1% increase in rainfall leads to a 0.002% increase in rice productivity.

Soybeans

A multiple regression model in double-log form was employed to analyze the correlation between soybean **productivity** per feddan (as the dependent variable) and a set of climatic factors (as independent variables) spanning the years 2000-2022. However, the overall significance of the model was not statistically validated

$$\ln Yt = 1.339 - 0.892 \ln X_1 - 0.591 \ln X_2 + 0.321 \ln X_3 + 0.055 \ln X_4$$

$$(-0.98)^{-} \quad (1.03)^{-} \quad (1.06)^{-} \quad (0.83)^{-}$$

$$R^2 = 0.098 \qquad F = 0.52$$

The R-squared value of 0.098 indicates that approximately 0.098% of the variation in soybean productivity can be explained by the included climatic factors. The F-statistic was about 0.52, showed that the overall model is statistically insignificant.

Impact of climate change on the productivity of the studied crops and estimation of the resultant economic losses

Data in Table 6 showed the cultivated area, production, and productivity of studied crops-maize, rice, and soybean-by different climatic regions for working out the value of loss due to cultivation of these crops in different climatic regions.

Table 6. Quantifying economic losses from climate-induced productivity changes in major crops (2021-2022)

Year	Region	1 Average production (tons/ feddan)	2 Area (feddan)	3 Price per ton	4 Production differentials (Ton)	5 lost production (Ton)	6 Value of lost production thousand L.E	7 The impact on farmers' income (L.E/ feddan)
Maize								
2021	**Lower Egypt**	3.603	1093174	4157.14	-	-	-	
	Middle Egypt	3.093	585958	4157.14	-	-	-	
	Upper Egypt	2.881	451717	4178.57	-	-	-	
	Outside the Valley	3.407	116054	4235.71	-	-	-	
2022	**Lower Egypt**	3.44	932918	9771.43	-	-	-	
	Middle Egypt	3.095	637954	9785.71	-	-	-	
	Upper Egypt	2.688	297540	9771.43	-	-	-	
	Outside the Valley	3.403	131789	9792.86	-	-	-	
Magnit ing Loss	**Lower Egypt**	-	-	6964.29	0.163	178187.4	1240947558	1135.178
	Middle Egypt	-	-	6971.43	0.002	1171.92	8169952.39	13.94285
	Upper Egypt	-	-	6975	0.193	87181.38	608090126	1346.175
	Outside the Valley	-	-	7014.29	0.004	464.22	3256171.38	28.05714
Overall maize harvest							1860463808	2523.353
Rice								
2021	**Lower Egypt**	3.841	1102717	5964	-	-	-	
	Middle Egypt	3.162	2089	5992	-	-	-	
	Upper Egypt	-	-	-	-	-	-	
	Outside the Valley	3	56	5998	-	-	-	
2022	**Lower Egypt**	3.743	1143.01	14953	-	-	-	
	Middle Egypt	3.528	6268	14981	-	-	-	
	Upper Egypt	-	-	-	-	-	-	
	Outside the Valley	3.222	158	14982	-	-	-	
Magnitud g Loss	**Lower Egypt**	-	-	13440.5	0.098	108066.3	1452464702	1317.169
	Middle Egypt	-	-	13482.5	0.366	764.574	10308369	4934.595
	Upper Egypt	-	-	-	-	-	-	-
	Outside the Valley	-	-	13489	0.222	12.432	167695.248	2994.558
Overall rice harvest							1462940766	9246.322
Soybean								
2021	**Lower Egypt**	**1.233**	**8337**	**18067**	**-**	**-**	**-**	
	Middle Egypt	**1.296**	**37906**	**18068**	**-**	**-**	**-**	
	Upper Egypt	1.115	2597	18080	-	-	-	
	Outside the Valley	1.377	212	18055	-	-	-	
2022	**Lower Egypt**	1.47	14774	21955	-	-	-	
	Middle Egypt	1.278	67735	21952	-	-	-	
	Upper Egypt	1.461	5532	21961	-	-	-	
	Outside the Valley	1.5	212	21983	-	-	-	
Magnitud g Loss	**Lower Egypt**	-	-	29044.5	0.237	1975.869	57388127.2	6883.547
	Middle Egypt	-	-	29044	0.018	682.308	19816953.6	522.792
	Upper Egypt	-	-	29060.5	0.346	898.562	26112661	10054.93
	Outside the Valley	-	-	29046.5	0.123	26.076	757416.534	3572.72
Overall soybean harvest							104075158	21033.99

Productivity Difference (4) = Productivity in the current year - productivity in the previous year

Lost Production (5) = (4) * (2)

Value of Lost Production (6) = (5) * (3)

Impact on Farmer Income (7) = (4) * (3)

Note: The average farm-gate price (3) was estimated for the unit of crop for the years 2021 and 2022.

Source: Collected and calculated from the Ministry of Agriculture, Central Department of Agricultural Economics, published data.

Maize productivity was the highest in the North Delta region averaged 3,603 and 3,440 tons/feddan in 2021 and 2022, respectively, losses that could arise from a difference in productivity per feddan induced by climate change were estimated at about 1860.5 million Egyptian pound during the same period. Which contributed to a loss about 2523.35 L.E/feddan to farmers' income.

Similarly, the table shows that the rice productivity was the highest in the Northern Delta region was 3.841 and 3.743 tons/ feddan in 2021 and 2022, respectively. Due to these losses resulting from the differences in productivity per feddan attributed to climate change were estimated at approximately 1462.9 million Egyptian pound in the same two years. That represents the loss of around 9246.322 L.E/feddan to farmers from their Income.

On the other hand, soybean showed the highest productivity in the Nubaria region (outside the valley), with an average of 1.377 and 1.500 tons/feddan in 2021 and 2022, respectively. As a result of the difference in productivity per feddan, the losses resulting from the difference in productivity per feddan due to climate change were estimated at approximately 104.1 million L.E during the same two years. This represents a loss of approximately 21033.99 L.E/feddan to farmers' income.

Quantifying the economic losses from climate-induced crop productivity reductions in the study sample

The data in Table 7 indicates the area, production, and productivity of the study crops (Maize, rice, and soybeans) according to the data of the field study sample to estimate the value of losses resulting from cultivating the study crops during the agricultural seasons 2022/2023 and 2023/2024. It appears that the productivity of one feddan of Maize decreased-about 0.69 tons/feddan-due to the impact of climate change during 2023/2024 in comparison with 2022/2023. While the losses that resulted from the difference in productivity per feddan due to climate change during the same two seasons were estimated at about 11582.13 thousand L.E due to the difference in productivity per feddan. Also, the average area of the crop cultivated for the two years of the study amounted to about 1488.78 feddans, and thus the amount of decrease in total production (lost production) due to climate change amounted to about 1027.26 tons, which means there is a loss in the value of agricultural production from the Maize crop and the impact of these losses on the farmer's income is about 7779.6 L.E/feddan.

While in the same table, it is showing a decrease in the productivity of one feddan of rice because of climate change impacts in 2023/2024 as compared to the year 2022/2023 by about 0.60 tons/feddan. The eventual differences in productivity per feddan led to the estimation of losses due to the climate change-induced difference in productivity per feddan at approximately 207000 L.E during the same two seasons. In addition, the average area of the crop cultivated for the two years of the study reached about 18.9 feddans, and thus, the amount of decrease in total production (lost production) because of climate change reached about 13.36 tons, which means that the loss of value in agricultural production from the rice crop, and the impact of those losses on the income of the farmer is about 9295.2 L.E/feddan.

In the meantime, it was found that due to climate change, the productivity of one feddan of soybeans decreased during 2023/2024, compared to 2022/2023, by about 0.46 tons/ feddan. Since the difference in productivity per feddan ensues, the losses resulting from the difference in productivity per feddan due to climate change were estimated at about 19.31 thousand Egyptian pounds during the two seasons. The overall average area of the crop cultivated for the two years of the study was about 1.68 feddans, hence the amount of decrease in total production due to climate change has amounted to approximately 0.77 tons; this infers that there is a loss in agricultural production value resulting from the soybean crop, amounting to about 11496.3 L.E/feddan, given the impact of these losses on farmers' incomes.

Level of environmental awareness regarding climate change among the studied sample

Data in Table 8 show that 88.2% of the respondents recorded low to moderate levels of environmental awareness about climate change

Table 7. Productivity indicators and estimated economic losses due to climate change impacts on maize, rice, and soybean for the 2022/2023 and 2023/2024 Seasons

Season/ Item	Indicators	Maize	Rice	Soybean
2022/2023	Cultivated Area (Feddan) (1)	1488.78	18.9	1.68
	Productivity (tons/ Feddan) (2)	3.78	3.49	1.82
	Total Production (tons) (3)	5627.5884	65.96	3.0576
2023/2024	Cultivated Area (Feddan) (4)	1488.78	18.2	1.68
	Productivity (tons/ Feddan) (5)	3.09	2.89	1.36
	Total Production (tons) (6)	4600.3302	52.598	2.2848
Change*	Cultivated Area %) (7)	-	-	-
	Productivity (% (8)	- 18.25	-17.19	-25.27
	Total Production (%) (9)	- 18.25	-20.26	-25.27
Productivity Difference (tons/ Feddan) (10) = 5-2		0.69	0.60	0.46
Lost Production (tons) (11) = 6-3		1027.26	13.36	0.77
2022/2023		9769.6	14984	21984
2023/2024		12780	16000	28000
Average Farm-Gate Price (EGP/ton) (12)		11274.8	15492	24992
Value of Lost Production (thousands EGP)(13)= (11) *12)		11582.13	207.00	19.31
Impact on Farmer Income (EGP/ Feddan) (14)= (12)* (10)		7779.6	9295.2	11496.3

Source: Collected and calculated from field study data for the 2022/2023 and 2023/2024 seasons.

Table 8. Distribution of respondents according to levels of environmental awareness of climate change (N = 169)

Level of Environmental Awareness	Frequency	%
Low (Below 43 points)	101	59.8
Medium (43-Below 60 points)	48	28.4
High (60 points and above)	20	11.8
Mean	42.99	
Standard Deviation	13.259	

Source: Calculated from field study data.

Data in Table 9 showed the average score for each item was taken to estimate the level of awareness of the respondents in each item regarding climate change, as shown in the environmental awareness scale. Generally speaking, the average score of the awareness of the respondents with regards to the items and indicators of the environmental awareness about climate change was 1.65 out of 3, or 55.11%. It was apparent from the description of research results that 17 items and indicators of environmental awareness of respondents about climate change got a low level of awareness, with 65.4% of the total number of items and indicators. Meanwhile, 7 items had an average level of awareness among the respondents with 26.9%, while only 2 items had a high level of awareness with 7.7% (Table 9).

Based on the data in Table 10, it is evident that only two of the environmental awareness indicators exhibited a high level of awareness among the respondents: a decrease in honeybee productivity with an average score of 2.45, and farmer awareness and advisory services regarding climate change with an average score of 2.43. Conversely, seven items demonstrated a moderate level of awareness: decreased productivity of vegetable and fruit crops (1.87), excessive fuel consumption (1.78), exceeding the required plant density (1.77), using crops and varieties that require less water (1.75), excessive irrigation practices (1.75), recycling agricultural and household waste (1.75), and decreased productivity of fish farms (1.72).

The results revealed a decrease in the average awareness scores for seventeen items: expanding organic farming (1.69), burning agricultural waste (1.66), declining crop productivity (1.62), excessive use of pesticides (1.62), using clean energy sources (1.56), decreased livestock productivity (1.56), poor plant growth (1.54), neglecting livestock hygiene (1.53), using heat-, salt-, and drought-tolerant varieties (1.51), excessive use of fertilizers (1.50), incidence of agricultural pests and diseases (1.49), deforestation (1.49), decreased egg and broiler production (1.46), decreased cereal crop production (wheat, rice, corn) (1.44), rationalizing the use of chemical fertilizers (1.39), improving agricultural practices and weed control (1.36), and decreased fodder crop production (1.32). This means that there is a need for awareness raising about these indicators to enable adaptation and mitigation of the impacts of this global phenomenon.

The findings necessitate that planners and implementers of training and advisory programs consider the study results in designing awareness raising programs for the respondents in terms of knowledge, information, and advisory practices on approaches to address climate change; this will eventually help the respondents protect their crops against climate change and improve their livelihood.

Identifying differences in the level of environmental awareness regarding climate change in the two study villages

To verify the study hypothesis that there are no statistically significant differences between the mean levels of environmental awareness regarding climate change in Mit Kenana village (belonging to Toukh Center) and Marsafa village (belonging to Benha Center), the researcher conducted an Independent Samples T-Test, after ensuring that the test assumptions were met.

Table 9. Frequency distribution of mean awareness scores for survey respondents on environmental awareness of climate change items

Categories of Mean Awareness Scores	Number of Awareness Items and Indicators	Percentage
Items with Low Awareness (below 1.70)	**17**	**65.4**
Items with Moderate Awareness (1.70 - below 2.08)	**7**	**26.9**
Items with High Awareness (2.08 and above)	**2**	**7.7**

Source: Calculated from field study data.

Table 10. Averages and percentages of farmers' awareness levels regarding climate change indicators in the study sample

No	Climate Change Awareness Indicators	Always	Sometimes	Rarely	Average Awareness Score	Standard Deviation	%	Awareness Level
1	**Burning agricultural residues**	32	47	90	1.66	0.780	55.23	Low
2	**Excessive irrigation**	29	69	71	1.75	0.730	58.38	Medium
3	**Overuse of agricultural pesticides**	24	56	89	1.62	0.724	53.85	Low
4	**Excessive use of agricultural fertilizers**	23	38	108	1.50	0.725	49.90	Low
5	**Excessive fuel consumption**	31	69	69	1.78	0.738	59.17	Medium
6	**Exceeding optimal planting density**	33	64	72	1.77	0.756	58.97	Medium
7	**Neglect of livestock husbandry hygiene**	24	41	104	1.53	0.732	50.89	Low
8	**Deforestation**	22	38	109	1.49	0.716	49.51	Low
9	**Decreased productivity of cereal crops (wheat, rice, corn)**	11	53	105	1.44	0.616	48.13	Low
10	**Decreased forage crop productivity**	7	40	122	1.32	0.550	43.98	Low
11	**Stunted plant growth**	23	46	100	1.54	0.723	51.48	Low
12	**Crop productivity decline**	31	43	95	1.62	0.778	54.04	Low
13	**Increased incidence of pests and diseases**	20	43	106	1.49	0.700	49.70	Low
14	**Decreased livestock productivity (milk and meat)**	18	58	93	1.56	0.680	51.87	Low
15	**Decreased poultry productivity (eggs and meat)**	14	49	106	1.46	0.645	48.52	Low
16	**Decreased honey production**	90	65	14	2.45	0.645	81.66	Low
17	**Decreased fruit and vegetable production**	43	61	65	1.87	0.791	62.33	Medium
18	**Decreased aquaculture productivity**	43	36	90	1.72	0.845	57.40	Medium
19	**Improved agricultural practices and weed control**	15	31	123	1.36	0.641	45.36	Low
20	**Recycling agricultural and household waste**	31	64	74	1.75	0.748	58.19	Medium
21	**Expansion of organic farming**	31	55	83	1.69	0.764	56.41	Low
22	**Adoption of water-efficient crops and varieties**	47	33	89	1.75	0.865	58.38	Medium
23	**Reduced use of chemical fertilizers**	17	32	120	1.39	0.665	46.35	Low
24	**Use of clean energy sources**	37	20	112	1.56	0.830	51.87	Low
25	**Adoption of heat, salinity, and drought-tolerant varieties**	29	28	112	1.51	0.772	50.30	Low
26	**Farmer education and awareness on climate change**	93	56	20	2.43	0.696	81.07	High

Source: Calculated from field study data.

Table 11 reveals that the mean level of environmental awareness regarding climate change in Mit Kenana village was 43.37 with a standard deviation of 14.015. This is slightly higher than the mean level of environmental awareness in Marsafa village, which was 42.43 with a standard deviation of 12.159. However, a t-test yielded a value of 0.461 with a p-value of 0.645, which is greater than the significance level of 0.05. Therefore, there is no statistically significant difference at the 0.05 level between the mean levels of environmental awareness regarding climate change in the two study villages.

Hypothesis testing

Environmental awareness of climate change across different crops

One-way ANOVA was conducted by the researcher in testing the hypothesis of the study, which states that there is no significant statistical difference in the mean level of environmental awareness of climate change from the two study villages based on the primary crop cultivated. After confirming that the test assumptions were met, the results were as follows:

Table 12 revealed that the mean level of environmental awareness regarding climate change among rice farmers was significantly higher at 51.36 (standard deviation: 14.083) compared to maize farmers (mean: 41.94, standard deviation: 12.936) and soybean farmers (mean: 38.56, standard deviation: 8.457). An F-test had a significant result ($F = 5.614$, $p < 0.05$), indicating that there are statistically significant differences in the mean levels of climate change awareness among farmers cultivating different crops.

Data in Table 14 revealed statistically significant differences in the mean level of environmental awareness regarding climate change between maize and rice farmers. However, insignificant differences were found between maize and soybean farmers. This can also be said that there are significant differences in the levels of environmental awareness about climate change among rice and soybean farmers, but there is insignificant differences found between rice and soybean farmers.

Table 11. Comparison of mean environmental awareness of climate change across study villages

Village	Sample Size	Mean	Standard Deviation	t-value	p-value	Statistical Significance
Mit Kennana	100	43.37	14.015	0.461	0.645	**Not significant**
Marsafa	69	42.43	12.159			

Source: Calculated from field study data.

Table 12. Descriptive statistics for analysis of variance test

Crop	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Maize	138	41.94	12.936	1.101	39.76	44.12	26	76
Rice	22	51.36	14.083	3.003	45.12	57.61	28	72
Soybean	9	38.56	8.457	2.819	32.05	45.06	31	58
Total	169	42.99	13.259	1.02	40.97	45	26	76

Source: Calculated from field study data.

Table 13. Analysis of variance (ANOVA) for the difference in mean environmental awareness regarding climate change among respondents by crop

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	P-value	Significance
Between Groups	1871.127	2	935.563	5.614	0.004	
Within Groups	27662.849	166	166.644			**Significant**
Total	29533.976	168				

Source: Calculated from field study data

Table 14. Multiple comparisons of environmental awareness regarding climate change for the three crops

Crop (I)	Crop (J)	Mean Difference* (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Maize	Rice	-9.422*	2.963	.002	-15.27	-3.57
	Soybean	3.386	4.441	.447	-5.38	12.15
Rice	Maize	9.422*	2.963	.002	3.57	15.27
	Soybean	12.808*	5.108	.013	2.72	22.89
Soybean	Maize	-3.386	4.441	.447	-12.15	5.38
	Rice	-12.808*	5.108	.013	-22.89	-2.72

*. The mean difference is significant at the 0.05 level.

Source: Calculated from field study data

REFERENCES

Atlas of Egypt's climate, General Authority of Meteorology.

Central Agency for Public Mobilization and Statistics, Environmental Bulletins, various issues.

Central Agency for Public Mobilization and Statistics, Statistical Yearbook, Annual Bulletin of Environmental Statistics, (Part Two) Environmental Quality and Energy, Various Issues.

Darity, W.A. (2008). International Encyclopedia of the Social Sciences, 2nd Ed., Macmillan Reference, USA, 2: 78.

Fathi Abdullah Abu Reda Abdel Aziz, General Principles in Climatic Geography, Dar Al-Maarifa Al-Jami'a, Egypt, 2006.

The Intergovernmental Panel on Climate Change (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

https://www.un.org/ar/climatechange/what-is-climate-change.

Ministry of Agriculture - Central Administration of Agricultural Economics, Agricultural Statistics Bulletin, various issues.

Ministry of Agriculture - Central Administration of Agricultural Economics, Agricultural Prices Bulletin, various issues.

Moustafa Mohamed El-Saadany, et al, The Effect Of Economic Of Climate Changes On The Production Of The Main Cereal Crops In Egypt, Egyptian Journal of Agricultural

Economics, Volume 27, Issue 3, September 2017.

Public Policy Forum, Policy Brief 37 From Policy to Implementation: Adapting to the Impacts of Climate Change on Agriculture in Egypt, The American University in Cairo, November 2022.

Wael Abdel-Fattah Abdel-Gaid Goueli, Estimating the effects of some climate changes on the productivity of some agricultural crops in Egypt, Egyptian Journal of Agricultural Economics, Volume 33, Issue 1, March 2023.

World Data Center for Greenhouses Gases (WDCGG) .

Zaied, Y. B. (2013). Long Run Versus Short Run Analysis of Climate Change Impacts on Agriculture. In *Economic Research Forum Working Papers* (No. 808).

الأثر الاقتصادي والاجتماعي للوعي البيئي بالتغيرات المناخية علي إنتاجية بعض المحاصيل الزراعية في مصر (دراسة حالة محافظة القليوبية)

فاطمة أحمد مصطفي البطح[1] - رباب سعيد عبدالقادر محمد[2] - محمود مصطفي الهباق[1]

1- شعبة الاقتصاد الزراعي - قسم الاقتصاد الزراعي - كلية الزراعة – جامعة بنها – مصر

2- شعبة الإرشاد الزراعي - قسم الاقتصاد الزراعي - كلية الزراعة – جامعة بنها – مصر

يهدف البحث إلى دراسة إلى الاثار الاقتصادية والاجتماعية للتغيرات المناخية على الإنتاج الزراعي، مع التركيز على محاصيل مختلفة مثل الذرة الشامية والأرز وفول الصويا في محافظة القليوبية. حيث تم استخدام المنهج الوصفي والتحليلي للتركيز على تأثير العوامل المناخية على إنتاجية المحاصيل. حيث أظهرت النتائج زيادة في تركيزات غازات الدفيئة وارتفاع في درجات الحرارة، في حين انخفضت الرطوبة النسبية ومعدلات هطول الأمطار. أدى هذا إلى تغييرات ملحوظة في المساحات المزروعة والإنتاج والعائدات المحصولية للمحاصيل المدروسة. لوحظ أيضًا أن الذرة الشامية والأرز شهدا انخفاضًا كبيرًا في العائد وبالتالي واجها خسائر اقتصادية هائلة. كما تناول البحث درجة الوعي البيئي لدى المزارعين، وكشف أن المزارعين لديهم درجة وعي منخفضة إلى متوسطة بشأن التغيرات المناخية. تشير نتيجة أخرى إلى أن مزارعي الأرز يعبرون عن مستوى أعلى بكثير من الوعي البيئي مقارنة بمزارعي الذرة الشامية وفول الصويا. وتسلط نتائج هذا البحث الضوء على الحاجة الملحة لزيادة الوعي البيئي وتبني أساليب زراعية مستدامة من أجل الحد من آثار تغير المناخ على الإنتاج الزراعي. لذلك، يدعو ذلك إلى برامج توعية وتعليم وتواصل محددة للغاية للتكيف مع آثار تغير المناخ والتخفيف منها بين المزارعين. كما أكد هذا البحث الحالي على الحاجة إلى سياسات وتدخلات لدعم المزارعين للتعامل مع آثار تغير المناخ على الأمن الغذائي في مصر.

المحكمـــــون:

1- أ.د. هديل طاهر حســـانين أستاذ الاقتصاد الزراعي - كلية الزراعة - جامعة الزقازيق.

2- أ.د. سامي أحمد عبد الجواد أستاذ الارشاد الزراعي - كلية الزراعة - جامعة بنها.