Climate and Environmental Change on the Productivity of Wheat and Barley Crops in the State of Palestine

Majd R. H. Hasanein [1], Mohamed O. Abdel Fatah[2], Ibrahim A. Abdel Fatah[3]

ABSTRACT

Greenhouse gas emissions in the agricultural sector result from several sources, the most important of which are nitrate dioxide (N2O) emissions resulting from the use of nitrogenous fertilizers to fertilize the soil, as well as methane emissions from internal fermentation, and emissions of CH4 and N2O gases resulting from organic fertilizer management, as well as pollution of agricultural drainage water with residues of chemical fertilizers and pesticides, on which most current agricultural methods depend. The study aims to demonstrate the impact of climate change on the productivity of both wheat and barley crops in the State of Palestine during the period (2007-2021), by estimating the multiple regression model in the double logarithmic form, where it was shown that increasing both the average maximum temperatures and the annual average rainfall rate by 1% leads to a decrease in wheat productivity by 1.04% and 0.27% for each of them, respectively, from the average wheat productivity in the State of Palestine, which amounted to about 2.08 tons/hectare during the study period, while increasing the annual average wind speed and the annual average wind speed by 1% for each of them leads to an increase in wheat productivity by 1.47% and 2.47% for each of them, respectively, from the average wheat productivity in the State of Palestine. The adjusted coefficient of determination reached 0.66, meaning that 66% of the changes occurring in the average wheat productivity in the State of Palestine are due to the changes occurring in both the average maximum temperatures and the average humidity, taking the degrees of freedom into account. While increasing the annual average rainfall rate by 1% leads to a decrease in barley productivity by 0.53% of the average barley productivity in the State of Palestine, which is about 2.17 tons/hectare during the study period, while increasing the annual average wind speed, the annual average wind speed by 1% for each of them leads to an increase in barley productivity by 2.44%, 3.94% for each of them respectively of the average barley productivity in the State of Palestine. The adjusted coefficient of determination reached 0.85, meaning that 85% of the changes occurring in the average barley productivity in the State of Palestine are due to the changes occurring in both the average maximum temperatures and the average humidity, taking the degrees of freedom into account.

Keywords: Climate change, hectare productivity, wheat and barley crops, State of Palestine, greenhouse gases.

INTRODUCTION

Climate change is one of the most important social and environmental determinants affecting human health, such as air and water, as rising temperatures and changing rainfall patterns lead to a decrease in food production in the world by about 50% (World Health Organization), and may lead to an increase in the prevalence of malnutrition and undernutrition, causing the death of more than about 3.1 million people annually. The Food and Agriculture Organization of the United Nations (FAO) indicates that the impact of climate change on food quality in the world is represented by threatening food security and decreasing the amount of water and rainfall patterns, which affects the supply of fresh water in the world. Agricultural ecosystems also contribute to the exacerbation of problems resulting from greenhouse gases, as the sources of greenhouse gas emissions in the agricultural sector are represented in emissions of nitrate dioxide gas N2O from the soil, especially as a result of nitrogen fertilization; methane emissions from internal fermentation and emissions of CH4, N2O gases as a result of natural fertilizer management, which greatly affects food production in the world, and contributes to the pollution of drinking water, whether with nitrates such as nitrogen fertilizers It is believed that agricultural methods that rely on chemical fertilization contribute to increased pollution. Climate change due to increased emissions of greenhouse gases leads to higher temperatures and thus the spread of infectious diseases in the world, the spread of epidemics that affect animals, which leads to a decrease in the amount of animal production, and a decrease in the amount of fish production by about 40%. It is also expected that climate change during the period until 2050 will lead to the death of more than 250 thousand people annually due to the spread of malnutrition, epidemics and heat stress.

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[1]Master's student, Department of Agricultural Economics, Faculty of Agric., Ain Shams Univ
[2]Professor, Department of Agricultural Economics, Faculty of Agric., Ain Shams Univ
[3]Assistant Professor, Department of Agricultural Economics, Faculty of Agric., Ain Shams Univ
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RESEARCH PROBLEM AND OBJECTIVES

The agricultural sector in Palestine faces several problems and challenges whose impact increases with successive years of change in temperature, relative humidity, fluctuations in rainfall and the increasing demand for agricultural products, with limited supply due to population growth, which led to a lack of self-sufficiency and a decline in the contribution of the agricultural sector to the gross domestic product to its lowest levels. As a result, there was a deterioration in the productivity of some grain crops in State of Palestine. The research aims to identify the impact of climate change (maximum temperatures, minimum temperatures, relative humidity, rainfall) on the productivity of some grain crops in Palestine.

RESEARCH METHOD AND DATA RESOURCES

The research relied on descriptive and quantitative analysis methods in describing and analyzing the topics it included and using some different statistical tools, including estimating the arithmetic mean and multiple regression analysis. The research also relied on secondary data sources: represented by secondary data published from its various sources such as the Central Agency for Public Mobilization and Statistics in Palestine, the Statistical Yearbook, and the Arab Organization for Agricultural Development.

Formulating a model of the impact of climate change on crop productivity:

Based on this, the climatic factors affecting the wheat crop were limited to the following equation:

$$\text{Ln } \hat{Y}_i = \propto + \beta_1 \text{ Ln } X_{i1} + \beta_2 \text{ Ln } X_{i2} + \beta_1 \text{ Ln } X_{i3} + \beta_1 \text{ Ln } X_{i4} + \beta_1 \text{ Ln } X_{i5} + \beta_1 \text{ Ln } X_{i6} + \beta_1 \text{ Ln } X_{i7} + \beta_1 \text{ Ln } X_{i8} + \beta_1 \text{ Ln } X_{i9} + \beta_1 \text{ Ln } X_{i10}$$

Where: $\hat{Y}_i$: Estimated value of crop productivity (tons/hectare) in the State of Palestine during the period (2007-2021).
X_{i1}: Annual average maximum temperature (degrees Celsius).
X_{i2}: Annual average minimum temperature (degrees Celsius).
X_{i3}: Annual average humidity rate (%).
X_{i4}: Annual average rainfall rate (mm).
X_{i5}: Annual average evaporation amount (mm).
X_{i6}: Annual average wind speed (km/h).
X_{i7}: Annual average amount of carbon dioxide gas (thousand tons CO2).
X_{i8}: Annual average amount of methane gas (thousand tons CO2 equivalent).
X_{i9}: Annual average degree of nitrous oxide gas (thousand tons CO2 equivalent).
X_{i10}: Annual average amount of emissions (thousand tons CO2 equivalent).

The result of the multiple model in the double logarithmic form concluded that the relationship between each of these variables and the dependent variable was not significant due to the presence of econometric problems, most notably the problem of multicollinearity, which was confirmed by the estimates of the simple correlation coefficients with the correlation coefficients matrix, while it became clear from the stepwise regression model that the most influential factors on crop productivity during the period (2007-2021).

RESULTS AND DISCUSSION

grain crops:

grain crops include wheat, rice, corn, barley, oats, rye, millet, sorghum, and buckwheat. The area of land cultivated with cereal crops in Palestine, according to the Palestinian Central Bureau of Statistics (preliminary results of the 2022 agricultural census), amounted to about 24.53 thousand hectares, representing about 91% in the West Bank and about 9% in the Gaza Strip; Jenin Governorate ranks first, followed by Hebron Governorate in second place. Table (1) and Figure (1), show the relative importance of the area of grain crops in the State of Palestine during the period (2018-2022), where wheat crop came in first place in terms of cultivated area, with an average area of about 16.41 thousand hectares, representing about 60.16% of the average cultivated area of total grains, which amounted to about 27.27 thousand hectares, while barley crop came in second place in terms of cultivated area, with an average area of about 6.55 thousand hectares, representing about 24.03% of the average cultivated area of total grains.

Table 1. The relative importance of the most important grain crops at the level of Palestine during the period (201 8-2022) **(Area: thousand hectares)**

Years	2018	2019	2020	2021	2022	Average	relative importance (%)
Wheat	29.19	15.3	15.15	8.49	13.9	16.41	60.16
Barley	9.13	7.52	7.19	3.66	5.271	6.55	24.03
Other Crops	0.50	1.15	0.44	12.38	7.09	4.31	15.81
Total Grains	38.82	23.97	22.78	24.53	26.27	27.27	100

Source: Compiled and calculated from: Statistical Yearbook, Arab Organization for Agricultural Development, various issues.

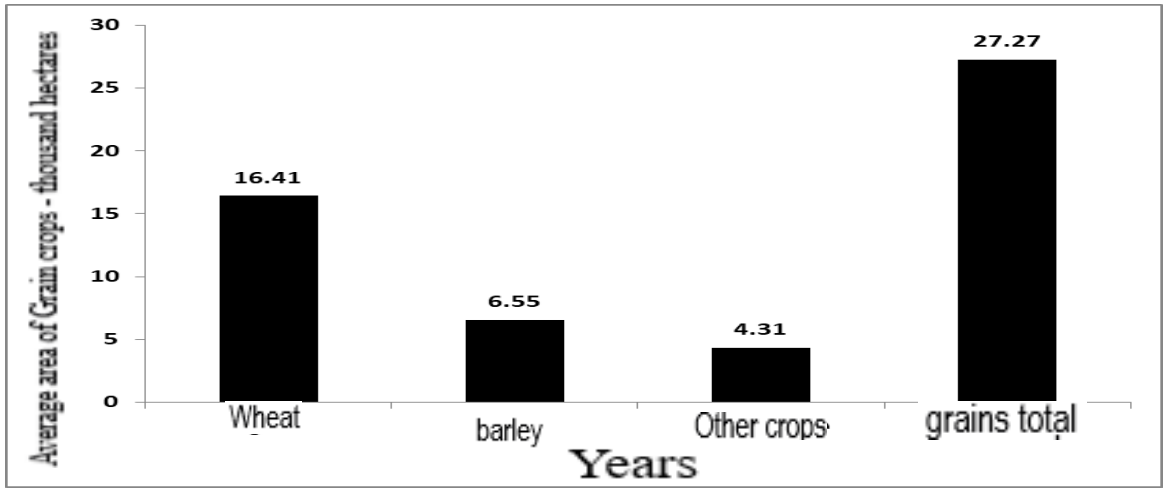

Fig. 1. The relative importance of the most important grain crops in Palestine during the period (2018-2022)
Source: Data from Table (1) of the study.

Development of total grain production in the State of Palestine:

A- Development of the total grain area in the State of Palestine:

It is clear from studying the indicators in Table (2) and Figure (2), that the total grain area in the State of Palestine during the study period (2007-2021) ranged between a minimum of about 15.69 thousand hectares in 2011 and a maximum of about 38.82 thousand hectares in 2018 with an annual average of about 26.34 thousand hectares during the study period. By studying the equation of the general time trend for the development of the total grain area in the State of Palestine in Table (3-3), it shows the results of the statistical estimate during the period (2007-2022), and from it it is clear that none of the known statistical images are significant, which means that the data on the total grain area in the State of Palestine revolves around its arithmetic average of about 26.34 thousand hectares during the study period, as it became clear that the significance of the model used for measurement in general was not proven using the calculated (F) value.

Table 2. Development of area, productivity and production of total grains at the level of Palestine during the period (2007-2022) (Area: thousand hectares, productivity: tons/hectare, production: thousand tons)

Years	Cultivated Area	Productivity	Production
2007	32.41	2.09	67.82
2008	34.55	1.57	54.16
2009	35.6	1.89	67.22
2010	18.66	2.01	37.44
2011	15.69	2.20	34.5
2012	18.58	2.40	44.57
2013	26.7	2.18	58.14
2014	27.18	2.17	59.11
2015	23.85	2.11	50.20
2016	23.49	2.45	57.61
2017	28.35	2.54	71.94
2018	38.82	2.27	88.24
2019	23.97	2.46	58.93
2020	22.78	2.22	50.66
2021	24.53	2.27	55.71
2022	26.27	2.31	60.77
Average	26.34	2.20	57.31
Minimum	15.69	1.57	34.50
Maximum	38.82	2.54	88.24

Source: Compiled and calculated from: Statistical Yearbook, Arab Organization for Agricultural Development, various issues.

B- Development of total grain productivity in the State of Palestine:

It is clear from studying the indicators in Table (2), that the total grain productivity in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 1.57 tons/hectare in 2008 and a maximum of about 2.54 tons/hectare in 2017 with an annual average of about 2.20 tons/hectare during the study period. By studying the equation of the general time trend for the development of total grain productivity in the State of Palestine in Table (3), it shows the results of the statistical estimate during the period (2007-2022), and from it it is clear that the total grain productivity in the State of Palestine took a general increasing trend by a statistically significant annual amount at a significance level of 0.01 and amounted to about 0.03 tons/hectare, representing about 1.49% of the average of about 2.20 tons/hectare. The coefficient of determination (R2) reached about 0.42, which means that 42% of the changes in the productivity of the total grains in the State of Palestine are due to factors that reflect the time element. The significance of the model used for measurement was generally proven using the calculated (F) value.

C- Development of the production of the total grains in the State of Palestine:

It is clear from studying the indicators in Table (2), that the production of the total grains in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 34.50 thousand tons in 2011 and a maximum of about 88.24 thousand tons in 2018 with an annual average of about 57.31 thousand tons during the study period. By studying the equation of the general time trend for the development of the production of the total grains in the State of Palestine in Table (3), it shows the results of the statistical estimate during the period (2007-2022), and from it it is clear that none of the known statistical images are significant, which means that the data on the production of the total grains in the State of Palestine revolve around its arithmetic average of about 57.31 thousand tons during the study period, as it became clear that the significance of the model used for measurement was not proven in general, using the calculated (F) value.

Development of wheat crop production in the State of Palestine:

A- Development of the wheat crop area in the State of Palestine:

It is clear from studying the indicators in Table (4) and Figure (3), that the wheat crop area in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 8.49 thousand hectares in 2021 and a maximum of about 29.19 thousand hectares in 2018 with an annual average of about 16.19 thousand hectares during the study period. By studying the equation of the general time trend for the development of the wheat crop area in the State of Palestine in Table (5), it shows the results of the statistical estimate during the period (2007-2022), and from it it is clear that none of the known statistical images are significant, which means that the data on the wheat crop area in the State of Palestine revolves around its arithmetic average of about 16.19 thousand hectares during the study period, as it became clear that the significance of the model used for measurement in general was not proven using the calculated (F) value.

Table 3. Equations of the time trend for the development of the area, productivity and production of total grains at the level of Palestine during the period (2007-2022)

NO.	Dependent variable	Estimated model	R^2	F	(%) annual change *
١	Cultivated area	None of the conventional statistical methods have been proven significant.			
٢	Productivity	$\hat{Y}_i = 1.92 + 0.03\ X_i$ (19.3)** (3.18)**	0.42	10.10	1.49
٣	Production	None of the conventional statistical methods have been proven significant.			

- Annual change = Regression coefficient /Average * 100

Where: Ŷi: Estimated value of the dependent variable.

Xi: Time variable where i = (1, 2, 3, ..., 16).

The value in parentheses indicates the calculated value of (T), (R^2) the coefficient of determination, (F) the significance of the model as a whole.

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

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

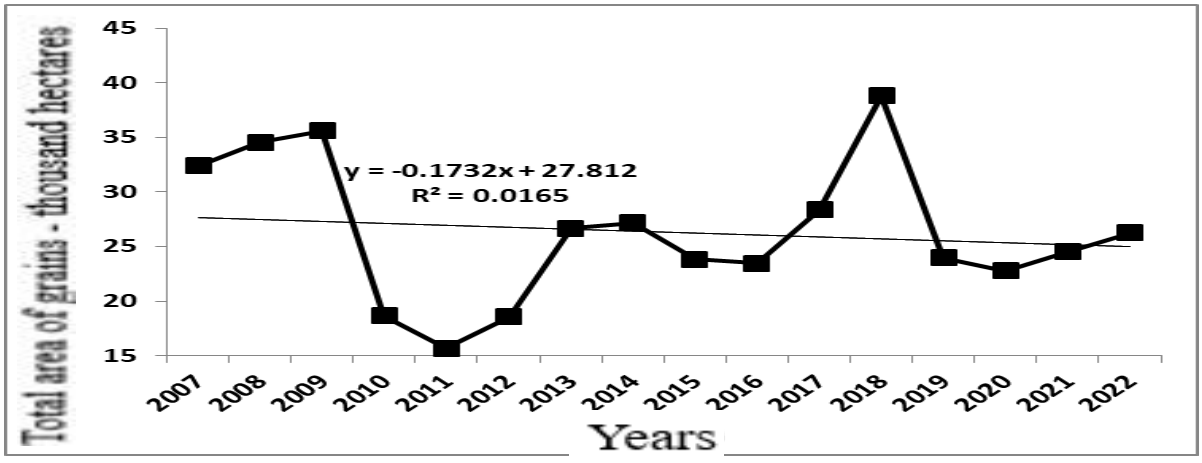

Fig. 2. Development of the total area of grains at the level of Palestine (thousand hectares) during the period (2007-2022)

Source: Data from Table (3-2) of the study.

Table 4. Development of area, productivity and production of wheat crops at the level of Palestine During the period (2007-2022)

(Area: thousand hectares, productivity: tons/hectare, production: thousand tons)

Years	Cultivated Area	Productivity	Production
2007	20.23	1.97	39.80
2008	22.94	1.39	31.83
2009	22.00	1.36	30.00
2010	9.71	1.79	17.38
2011	11.00	1.62	17.84
2012	13.34	2.00	26.67
2013	17.36	2.40	41.72
2014	17.36	2.40	41.72
2015	13.27	1.98	26.32
2016	14.40	2.57	37.03
2017	15.46	2.24	34.56
2018	29.19	2.37	69.08
2019	15.30	2.25	34.37
2020	15.15	2.27	34.37
2021	8.49	2.32	19.66
2022	13.91	2.36	32.81
Average	16.19	2.08	33.45
Minimum	8.49	1.36	17.38
Maximum	29.19	2.57	69.08

Source: Compiled and calculated from: Statistical Yearbook, Arab Organization for Agricultural Development, various issues.

B- Development of wheat crop productivity in the State of Palestine:

It is clear from studying the indicators in Table (4), that wheat crop productivity in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 1.36 tons/hectare in 2009 and a maximum of about 2.57 tons/hectare in 2016 with an annual average of about 2.08 tons/hectare during the study period. By studying the equation of the general time trend for the development of wheat crop productivity in the State of Palestine in Table (5), it shows the results of the statistical estimate during the period (2007-2022), and it is clear from it that the total wheat crop productivity in the State of Palestine took a general increasing trend by a statistically significant annual amount at a significance level of 0.01, and amounted to about 0.06 tons/hectare, representing about 2.72% of the average of about 2.08 tons/hectare. The coefficient of determination (R2) reached about 0.53, which means that 53% of the changes in wheat crop productivity in the State of Palestine are due to factors that reflect the time element. The significance of the model used for measurement was generally proven using the calculated (F) value.

Table 5. Equations of the time trend for the development of the area, productivity and production of wheat crops at the level of Palestine during the period (2007-2022)

NO.	Dependent variable	Estimated model	R^2	F	% annual change
١	Cultivated area	None of the conventional statistical methods have been proven significant.			
٢	Productivity	$\hat{Y}_i = 1.6 + 0.06\ X_i$ (11.5)** (3.95)**	0.53	15.59	2.72
٣	Production	None of the conventional statistical methods have been proven significant.			

Where: Ŷi: Estimated value of the dependent variable.
Xi: Time variable where i = (1, 2, 3, ..., 16).
The value in parentheses indicates the calculated value of (T), (R2) the coefficient of determination, (F) the significance of the model as a whole.
(**) indicates the significance of the regression coefficient at the significance level of 0.01.
Source: Calculated from data in Table (2) of the study.

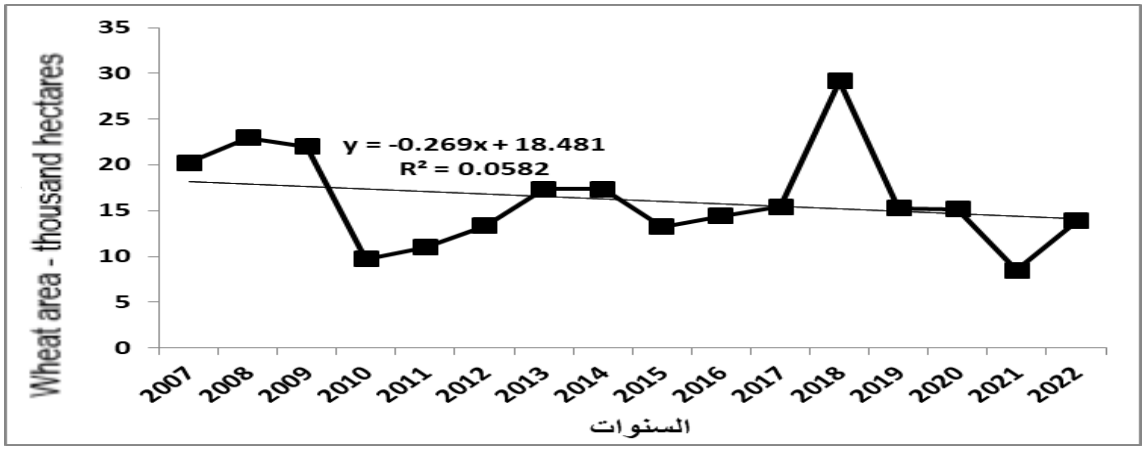

Fig. 3. Development of wheat crop area at the level of Palestine (thousand hectares) during the period (2007-2022)

Source: Data from Table (4) in the study.

C- Development of wheat crop production in the State of Palestine:

It is clear from studying the indicators in Table (4), that wheat crop production in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 17.38 thousand tons in 2010 and a maximum of about 69.08 thousand tons in 2018 with an annual average of about 33.45 thousand tons during the study period. By studying the equation of the general time trend for the development of wheat crop production in the State of Palestine in Table (5), it shows the results of the statistical estimate during the period (2007-2022), and from it it is clear that none of the known statistical images are significant, which means that the wheat crop production data in the State of Palestine revolve around Its arithmetic average was about 33.45 thousand tons during the study period, as it became clear that the significance of the model used for measurement was not proven in general, using the calculated (F) value.

The impact of climate change on wheat crop productivity in the State of Palestine:

After conducting many attempts to reach the most important climatic factors affecting wheat crop productivity in the State of Palestine, it is clear from the multiple regression model in the double logarithmic image of the impact of climate change on wheat crop productivity in the State of Palestine during the period (2007-2021) that increasing each of the average maximum temperatures, the annual average rainfall rate by 1% leads to a decrease in wheat productivity by 1.04%, 0.27% for each of them respectively from the average wheat productivity in the State of Palestine, which amounted to about 2.08 tons/hectare during the study period, while increasing the annual average wind speed, the annual average wind speed by 1% for each of them leads to an increase in wheat productivity by 1.47%, 2.47% for each of them respectively from the average wheat productivity in the State of Palestine. The adjusted coefficient of determination reached 0.66, meaning that 66% of the changes in the average wheat productivity in the State of Palestine are due to the changes in both the average maximum temperature and the average humidity, taking the degrees of freedom into account. The significance of the model as a whole was proven, as the F value reached about 7.69.

$$\text{Ln } \hat{Y}_i = 3.07 - 1.04 \text{ Ln } X_{i1} - 0.27 \text{ Ln } X_{i4} + 1.47 \text{ Ln } X_{i6} + 2.47 \text{ Ln } X_{i8}$$

(1.11) (-1.70) (-1.96)* (2.77)** (4.41)**

$R^2 = 0.76$ $\bar{R}^2 = 0.66$ F = 7.69

where:

$\hat{Y}_i$: Average wheat crop productivity in Palestine tons/acre.

X_{i1}: Average maximum temperature degrees Celsius.

X_{i4}: Average annual rainfall rate (mm).

X_{i6}: Average annual wind speed (km/h).

X_{i8}: Average annual methane gas quantity (thousand tons CO2 equivalent).

Source: Results of statistical analysis using SPSS for data in Table (4) of the research, (1) in the appendices.

Development of barley crop production in the State of Palestine:

A- Development of barley crop area in the State of Palestine:

It is clear from studying the indicators of Table (6) and Figure (4), that the barley crop area in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 15.69 thousand hectares in 2011 and a maximum of about 38.82 thousand hectares in 2018 with an annual average of about 26.34 thousand hectares during the study period. By studying the equation of the general time trend of the development of the barley crop area in the State of Palestine in Table (7), it shows the results of the statistical estimation during the period (2007-2022), and from it it becomes clear that the cubic image is the best image from a statistical point of view, as the barley crop area in the State of Palestine tended towards decreasing until it reached the lowest area of about 4.15 thousand hectares in 2011, then it took an increase until it reached the maximum area of about 10.02 thousand hectares in 2015, then it took a general decreasing trend by a statistically significant annual amount at a significance level of 0.01, reaching about 0.12 thousand hectares, representing about 1.65% of the average of about 7.26 thousand hectares during the period (2016-2022). The coefficient of determination (R2) reached about 0.51, which means that 51% of the changes in the area of barley crop in the State of Palestine are due to factors that reflect the time element. The significance of the model used for measurement was generally proven using the calculated (F) value.

Table 6. Development of the area, productivity and production of barley crop at the level of Palestine During the period (2007-2022) (Area: thousand hectares, productivity: tons/hectare, production: thousand tons)

Years	Cultivated Area	Productivity	Production
2007	11.11	1.35	14.96
2008	10.76	0.91	9.74
2009	11.00	0.89	9.80
2010	4.30	2.02	8.70
2011	4.15	1.39	5.77
2012	4.60	1.80	8.29
2013	9.28	1.77	16.38
2014	9.28	1.77	16.38
2015	10.02	2.28	22.80
2016	8.73	2.26	19.70
2017	9.34	2.10	19.63
2018	9.13	2.00	18.23
2019	7.52	2.04	15.33
2020	7.19	2.12	15.26
2021	3.66	2.13	7.78
2022	5.27	2.17	11.45
Average	7.83	1.81	13.76
Minimum	3.66	0.89	5.77
Maximum	11.11	2.28	22.80

Source: Compiled and calculated from: Annual Statistical Book, Arab Organization for Agricultural Development, various issues.

B- Development of barley crop productivity in the State of Palestine:

It is clear from studying the indicators in Table (6), that the productivity of barley crop in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 0.89 tons/hectare in 2009 and a maximum of about 2.28 tons/hectare in 2015 with an annual average of about 1.81 tons/hectare during the study period. By studying the equation of the general time trend for the development of barley crop productivity in the State of Palestine in Table (7), it shows the results of the statistical estimate during the period (2007-2022), and it is clear from it that the total productivity of barley crop in the State of Palestine It took a general trend of increasing by a statistically significant annual amount at a significance level of 0.01 and amounted to about 0.07 tons/hectare, representing about 4.03% of the average amounting to about 1.81 tons/hectare. The coefficient of determination (R2) amounted to about 0.60, which means that 60% of the changes in barley crop productivity in the State of Palestine are due to factors that reflect the time element. The significance of the model used for measurement was generally proven using the calculated (F) value of about 21.04.

C- Development of barley production in the State of Palestine:

It is clear from studying the indicators in Table (6), that barley production in the State of Palestine during the study period (2007-2022) ranged between a minimum of about 5.77 thousand tons in 2011 and a maximum of about 22.80 thousand tons in 2015 with an annual average of about 13.76 thousand tons during the study period. By studying the equation of the general time trend of the development of barley production in the State of Palestine in Table (7), it shows the results of the statistical estimation during the period (2007-2022), and from it it becomes clear that the cubic image is the best image from a statistical point of view, as barley production in the State of Palestine tended towards decreasing until it reached the lowest production of about 5.77 thousand tons in 2011, then it began to increase until it reached the maximum production of about 22.80 thousand tons in 2015, then it took a general decreasing trend by a statistically significant annual amount at a significance level of 0.01 and amounted to about 0.24 thousand tons, representing about 1.56% of the average, which amounted to about 15.34 thousand tons during the period (2016-2022). The coefficient of determination (R2) reached about 0.65, which means that 65% of the changes in barley production in the State of Palestine are due to factors that reflect the time element. The significance of the model used for measurement was generally proven using the calculated (F) value.

Table 7. Equations of the time trend for the development of the area, productivity and production of barley crops at the level of Palestine during the period (2007-2022)

NO.	Dependent variable	Estimated model	R^2	F	% annual change
١	Cultivated area	$\hat{Y}_i = 15.2 - 3.79\ X_i$ (5.7)** (-2.9)** $+ 0.53\ X_i^2 - 0.02\ X_i^3$ (2.98)** (-3.07)**	0.51	4.23	--
٢	Productivity	$\hat{Y}_i = 1.19 + 0.07\ X_i$ (7.7)** (4.59)**	0.60	21.04	4.03
٣	Production	$\hat{Y}_i = 17.1 - 4.91\ X_i$ (3.9)** (-2.30)* $+ 0.91\ X_i^2 - 0.04\ X_i^3$ (3.15)** (-3.59)**	0.65	7.37	--

Where: Ŷi: Estimated value of the dependent variable.
Xi: Time variable where i = (1, 2, 3, ..., 16).
The value in parentheses indicates the calculated value of (T), (R^2) the coefficient of determination, (F) the significance of the model as a whole.
(**) indicates the significance of the regression coefficient at the significance level of 0.01.
Source: Calculated from data in Table (2) of the study.

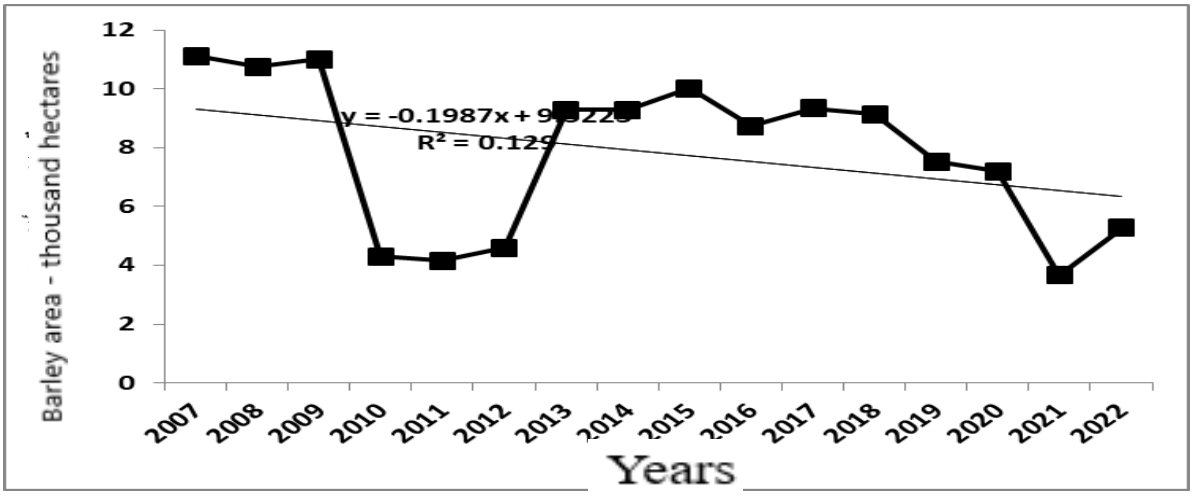

Fig. 4. Development of barley crop area at the level of Palestine (thousand hectares) during the period (2007-2022)

Source: Data from Table (6) of the study.

The impact of climate change on barley productivity in the State of Palestine: After making many attempts to reach the most important climatic factors affecting barley productivity in the State of Palestine, it is clear from the multiple regression model in the double logarithmic image of the impact of climate change on barley productivity in the State of Palestine during the period (2007-2021) that increasing the annual average rainfall rate by 1% leads to a decrease in barley productivity by 0.53% of the average barley productivity in the State of Palestine, which amounted to about 2.17 tons/hectare during the study period, while increasing the annual average wind speed, the annual average wind speed by 1% for each of them leads to an increase in barley productivity by 2.44%, 3.94% for each of them respectively of the average wheat productivity in the State of Palestine. The adjusted coefficient of determination reached 0.85, meaning that 85% of the changes in the average barley productivity in the State of Palestine are due to the changes in both the

average maximum temperature and the average humidity, taking the degrees of freedom into account. The significance of the model as a whole was proven, as the F value reached about 27.24.

$$\mathbf{Ln\ \hat{Y}_i = -6.19 - 0.53\ Ln\ X_{i4} + 2.44\ Ln\ X_{i6} + 3.94\ Ln\ X_{i8}}$$

(-2.47)* (-3.69)** (4.59)** (7.22)**

$R^2 = 0.88$ $\bar{R}^2 = 0.85$ $F = 27.24$

where:

$\hat{Y}_i$: Average wheat crop productivity in Palestine tons/acre.

X_{i4}: Annual average rainfall (mm).

X_{i6}: Annual average wind speed (km/h).

X_{i8}:Annual average methane gas quantity (thousand tons CO2 equivalent).

Source: Results of statistical analysis using SPSS for data in Table (6) of the research, (1) in the appendices.

RECOMMENDATIONS

1- Work on providing and making available a database for agricultural crops in the State of Palestine.

2- Develop a plan for the crop structure for fluctuations in areas, productivity and production in the State of Palestine

3- The need to adapt to the potential effects of climate change, which cause losses in the average productivity of agricultural crops, such as providing varieties that are resistant to heat and humidity and resistant to stress.

4- Expand the study of the impact of climate and environmental changes on the productivity of agricultural crops and focus on the different varieties of each crop, as the negative effects of climate change on the productivity of the most important agricultural crops have been proven.

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الملخص العربي

أثر التغير المناخي والبيئي علي إنتاجية محصولي القمح والشعير في دولة فلسطين

مجد رائد حسين حسنين، محمد عثمان عبد الفتاح ، إبراهيم علي عبد الفتاح

تنتج إنبعاثات غازات الإحتباس الحراري في القطاع الزراعى من عدة مصادر أهمها إنبعاثات غاز ثاني أكسيد النترات N2O نتيجة أستخدام الأسمدة الأزوتية في تخصيب التربة، وكذلك إنبعاثات غاز الميثان من التخمير الداخلي، وانبعاثات غازات CH4، N2O نتيجة إدارة السماد العضوي، وكذلك تلوث مياه الصرف الزراعي بمتبقيات الأسمدة الكيماوية والمبيدات والتي تعتمد عليها معظم أساليب الزراعية الحالية.

وتستهدف الدراسة بيان أثر التغير المناخي علي إنتاجية كل من محصولي القمح والشعير في دولة فلسطين خلال الفترة (٢٠٠٧-٢٠٢١)، وذلك من خلال تقدير نموذج الانحدار المتعدد في الصورة اللوغاريتمية المزدوجة، حيث تبين أن بزيادة كل من متوسط درجات الحرارة العظمي، المتوسط السنوي لمعدل سقوط الأمطار بنسبة ١% يؤدي إلي انخفاض إنتاجية القمح بنسبة ١,٠٤%، ٠,٢٧% لكل منهما علي الترتيب من متوسط إنتاجية القمح بدولة فلسطين والبالغ حوالي ٢,٠٨ طن/هكتار خلال فترة الدراسة، في حين بزيادة المتوسط السنوي لسرعة الرياح، المتوسط السنوي لسرعة الرياح بنسبة ١% لكل منهما يؤدي إلي زيادة إنتاجية القمح بنسبة ١,٤٧%، ٢,٤٧% لكل منهما علي الترتيب من متوسط إنتاجية القمح بدولة فلسطين. هذا وقد بلغ معامل التحديد المعدل ٠,٦٦ أي أن ٦٦% في التغيرات الحادثة في متوسط إنتاجية القمح بدولة فلسطين ترجع إلي التغيرات الحادثة في كل من متوسط درجات الحرارة العظمي، ومتوسط الرطوبة مع أخذ درجات الحرية في الأعتبار. في حين بزيادة المتوسط السنوي لمعدل سقوط الأمطار بنسبة ١% يؤدي إلي انخفاض إنتاجية الشعير بنسبة 0.53% من متوسط إنتاجية الشعير بدولة فلسطين والبالغ حوالي ٢,١٧ طن/هكتار خلال فترة الدراسة، في حين بزيادة المتوسط السنوي لسرعة الرياح، المتوسط السنوي لسرعة الرياح بنسبة ١% لكل منهما يؤدي إلي زيادة إنتاجية الشعير بنسبة ٢,٤٤%، ٣,٩٤% لكل منهما علي الترتيب من متوسط إنتاجية الشعير بدولة فلسطين. هذا وقد بلغ معامل التحديد المعدل ٠,٨٥ أي أن ٨٥% في التغيرات الحادثة في متوسط إنتاجية الشعير بدولة فلسطين ترجع إلي التغيرات الحادثة في كل من متوسط درجات الحرارة العظمي، ومتوسط الرطوبة مع أخذ درجات الحرية في الأعتبار.

الكلمات المفتاحية: التغير المناخي، إنتاجية الهكتار، محصولي القمح والشعير، دولة فلسطين، غازات الإحتباس الحراري.

APPENDICES

Table 1. The development of the average of maximum and minimum temperatures, humidity, rainfall, wind speed, and emissions quantities in the State of Palestine during the period (2007-2021)

Years	Maximum temperature	Minimum temperature	Humidity rate	Rain amount	Evaporation amount	Wind speed	Carbon dioxide Net Net CO2	Methane gas CH4	Nitrous oxide N2O	Emission amounts
	Celsius		%	mm		km/h	(CO2)thousand tons equivalent			
2007	23.1	13.7	61.7	415.9	1815.0	8.6	1238.2	30.6	2.1	2526.8
2008	25.0	15.4	60.3	352.4	2026.5	6.4	1508.7	32.3	1.9	2776.7
2009	24.8	15.6	62.0	484.5	2065.0	7.2	1779.2	34.0	1.7	3026.6
2010	28.2	16.9	59.0	376.2	2143.5	7.4	2049.7	35.7	1.5	3276.5
2011	24.1	15.0	61.5	431.6	1931.3	7.6	1900.2	38.2	1.7	3226.3
2012	26.2	15.4	61.0	595.9	2105.3	7.5	2059.3	38.5	1.7	3380.6
2013	24.9	15.5	62.8	601.5	2065.0	7.3	2294.7	38.5	1.6	3612.0
2014	25.2	15.6	64.5	342.7	1944.5	6.1	3180.3	40.5	1.9	4614.9
2015	25.0	15.9	63.3	530.1	1937.2	6.3	3013.4	42.8	1.9	4961.0
2016	25.6	16.2	61.0	476.4	2054.1	6.1	3254.5	44.2	1.5	4645.5
2017	25.3	16.0	61.5	221.4	2029.5	5.6	3284.3	44.2	1.8	4777.2
2018	25.6	16.8	66.5	691.9	1964.9	5.5	2968.0	47.9	1.8	4527.7
2019	25.2	15.6	64.3	529.0	2009.2	5.7	3288.3	49.3	1.8	4879.6
2020	25.9	16.5	67.3	631.2	2007.0	5.4	3348.8	48.8	1.4	4829.4
2021	26.4	17.0	62.3	444.5	2109.7	5.9	3751.9	43.3	1.9	5259.5
Average	25.3	15.8	62.6	475.0	2013.8	6.6	2594.6	40.6	1.7	4021.4
Minimum	23.1	13.7	59.0	221.4	1815.0	5.4	1238.2	30.6	1.4	2526.8
Maximum	28.2	17.0	67.3	691.9	2143.5	8.6	3751.9	49.3	2.1	5259.5

Source: Compiled and calculated from: Statistical Yearbook, Arab Organization for Agricultural Development, various issues.