# Measuring the Economic Impact of Climate Change on Potatoes Production in Egypt (Behera Governorate Case Study)

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***Abstract:*** *The phenomenon of climate change represents an imbalance in the usual climatic conditions such as heat, wind, rain, and relative humidity, which leads to an impact on natural vital systems and as a result of climate changes, it is expected that the majority of crops will go through a deterioration in acre productivity, and the problem of the study is summarized in the presence of severe climatic changes in the main climate elements, which led to negative and positive effects on the acre productivity of agricultural crops in general and the Potatoes crop in particular, which pushes farmers to refrain from planting The crop later, so the study mainly aims to study and analyze the impact of climate change on Potatoes production in Behera Governorate by studying the development of productive indicators of the Potatoes crop, and measuring the impact of climate change on acre productivity, and its impact on total production, this research has used the descriptive method and the method of quantitative statistical analysis through the use of some The results of the research showed the extent to which the actual reality coincides with the economic logic that confirms that climate change leads to a change in agricultural productivity, as it was found through statistical analysis that the rise in the maximum temperature in February by one degree Celsius will lead to a decrease in the acre productivity of the crop by about 0.88%, and it was also found that the rise in The minimum temperature during the production months by one degree Celsius will lead to an increase and decrease in the acre productivity of the crop without a significant impact, and it was found that increasing the percentage of moisture by about 0.53% degrees will lead to an increase in the acre productivity of the crop by about 0.53% during the month of March, and the results of the research show that the increase in the amount of rain in November by about 0, 030 mm will lead to an increase in the acre yield of the crop by about 0.030%, while the results showed a statistically significant direct relationship between the total Potatoes production and both the average maximum temperature and relative humidity during the production months, and it was also found that there is an inverse relationship with the minimum temperature and total production and direct with rainfall but without significant.*

***Keywords:*** **Climate change, Egyptian Potatoes, Climate influences on agricultural production, Potatoes, water, Seasonal record**

## 1. INTRODUCTION

Agriculture is strongly linked to climatic conditions, where weather plays a primary role in agricultural production at both local and global levels. Moreover, 20-80% of the fluctuations in agricultural production in recent years are due to climate change. Approximately 26% of agricultural production losses in developing countries are caused by climate-related disasters. The phenomenon of climate change represents a disruption in normal climatic conditions such as temperature, wind, rainfall, and relative humidity, leading to an impact on natural biological systems. As a result of climate change, it is expected that the majority of crops will experience a decline in per-feddan productivity (United Nations, 2021).

Potatoes occupy an important position among food crops in many countries of the world and are considered the first alternative to grain crops in solving the food problem, and in Egypt the Potatoes crop is one of the main vegetable crops and is grown in Egypt in three nested lugs throughout the year winter, summer and indigo, where the area of the winter loop represents 64% of the area downloaded from potatoes as an average during the period (2019-2023), which plants its seedlings in August and October and produces its fruits In December, January and February, which were negatively affected by high temperatures, about 28% of the Potatoes area is planted in the summer loop while about 7% is planted in the Nile loop.(maha ahmed)

Accordingly, the winter loop was chosen to study the impact of climate change on the Potatoes crop in Egypt and the most important governorates of its production represented in Beheira Governorate.

***Study Problem:***

The problem of the study is the occurrence of sharp and sudden changes in the main elements of the climate, which led to the presence of negative and positive effects on Egyptian agricultural production, as the change in climatic conditions of temperature, humidity, rainfall rate and other factors, whether in excess or decrease from the optimum limit, leads to an impact on the stages and completion of the growth and maturity of the most important field crops in general and the Potatoes crop in particular, which affects in one way or another the acre productivity of the Potatoes crop, which leads to Economic effects are often represented in the decrease in acre productivity and thus a decrease in the net acre yield, and there are other effects that push farmers to refrain from planting the crop later, and this is negatively reflected on the orientations of the Egyptian state's policy in maintaining the production of strategic crops in agricultural plans.

***Study Objectives:***

The research mainly aims to measure the economic impact of climate change on Potatoes production in Egypt in Egypt and Behera Governorate during the period (2004-2023) through a set of the following sub-objectives:

1. Analysis of production indicators of Potatoes crop in Egypt and Behera Governorate.
2. Study of the index of important climatic factors affecting the Potatoes crop in Behera Governorate.
3. Measuring the impact of climate change on the productivity of the Potatoes crop in Behera Governorate.
4. Measuring the Impact of Climatic Elements on the Total Potatoes Production in Behera Governorate.

## 2. Research Methodology and Data Sources:

The study relied on a number of statistical and descriptive methods, which were represented in tabular presentation , percentages, averages, minimum and maximum, and simple and multiple regression analysis, The data used in the research were obtained from secondary sources, including the Ministry of Agriculture and Land Reclamation (Economic Affairs Sector), the Climate Change Knowledge Portal (World Bank Group), the Central Agency for Public Mobilization and Statistics (CAPMAS), as well as published studies and research related to the study's topic.

## 3. Research Findings

**First: Development of Production Indicators for the Potatoes Crop in Egypt and Al Behera Governorate**

**(A) Development of Production Indicators for the Potatoes Crop in Egypt:**

**(1) Cultivated Area:**

The data in Table (1) show that the area cultivated with Potatoes in Egypt during the period (2004-2023) ranged between a minimum of about 220 thousand feddans in 2006 and a maximum of about 585 thousand feddans in 2022, with an average of about 396 thousand feddans.

By estimating the equation of the general time trend, it was found from equation No. (1), in Table (2), that the area planted with the Potatoes crop has taken an increasing general trend, as the increase reached about 15.95 thousand acres annually, while the coefficient of determination was about 0.85, meaning that the changes reflected by time are responsible for 85% of the changes that occur in the area planted with potatoes, and the significance of the model has been proven at all probability levels.

**(2) Per-Feddan Productivity:**

By examining the data in Table (1), it is evident that the per-feddan productivity of the Potatoes crop in Egypt reached its highest level at approximately 10.27 tons/feddan in 2004, and its lowest level at about 13.41 tons/feddan during the years 2023, with an annual average of about 11.39 tons/feddan.

By estimating the general time trend equation, equation (2) in Table (2) showed that the acre productivity of the Potatoes crop has taken a general trend that is increasing statistically significant, as the rate of change was about 1.11% during the study period, while the coefficient of determination was about 0.83, which means that the changes reflected by the time factor were responsible for about 85%. of the changes in the acre productivity of the Potatoes crop during that period, and the statistical significance of the estimated model was proven at the probability level (0.001).

**(3) Total Production:**

It is clear from the data in Table (1) that the total production of the Potatoes crop in Egypt reached its highest level at approximately 7594 thousand tons in 2023, and its lowest level at about 2313 thousand tons in 2006, with an annual average of about 4593 thousand tons.

By estimating the equation of the general time trend, equation No. (3) in Table (2) showed that the total production of the Potatoes crop has taken a general trend increasing statistically significant, amounting to about 234.76 thousand tons, and the annual rate of increase was about 5.1% of the general average of the total production of potatoes, which was estimated at about 4593 thousand tons during the same The period , the coefficient of determination was about 0.88, which means that the changes reflected by the time factor were responsible for about 88% of the changes in the total production of the Potatoes crop, during that period, and the statistical significance of the estimated model was proven at the probability level (0.01).

**(B) Development of Production Indicators for the Potatoes Crop in Al Behera Governorate:**

**(1) Cultivated Area:**

Reviewing the data in Table (1), it is evident that the area cultivated with Potatoes in Al Behera Governorate reached its highest level at approximately 86 thousand feddans in 2012, while its lowest level was about 1 thousand feddans in 2023, with an annual average of about 64 thousand feddans, representing a percentage of about 16.96% of the Republic's total cultivated area.

By estimating the general time trend equation, equation No. (4) in Table (2) showed that the area planted with the Potatoes crop has taken an increasing general trend that is not statistically significant, as the significance of the model has not been proven.

**(2) Per-Feddan Productivity:**

The data in Table (1) indicate that the per-feddan productivity of the Potatoes crop in Al Behera Governorate reached its highest level at approximately 12.07 tons/feddan in 2013, while its lowest level was about 10.17 tons/feddan in 2004, with an annual average of about 10.99 tons/feddan.

By estimating the general time trend equation, equation No. (5) in Table (2) showed that the acre productivity of the Potatoes crop in the governorate has taken a general trend that is statistically significant, which was estimated at about 0.959 tons / acre during the study period, while the coefficient of determination was about 0.47, which means that the changes reflected by the time factor were responsible for about 47%. of the changes in the acre productivity of the Potatoes crop during that period, and the statistical significance of the estimated model was proven at the probability level (0.001).

**Table (1) Production Indicators for the Potatoes Crop in Egypt and Al Behera Governorate During the period (2004-2023)**

| Years | Egypt | | | Behera Governorate | | | | |
|---|---|---|---|---|---|---|---|---|
| | Area (1000 Fed.) | Yield (Ton/ Fed.) | Prod. (1000 Ton) | Area (1000 Fed.) | Yield (Ton/ Fed.) | Prod. (1000 Ton) | % of the area of the Republic | % for the production of the Republic |
| 2004 | 248 | 10.27 | 2547 | 43 | 10.17 | 435 | 17.26 | 17.10 |
| 2005 | 301 | 10.53 | 3167 | 55 | 10.51 | 577 | 18.27 | 18.22 |
| 2006 | 220 | 10.51 | 2313 | 41 | 10.48 | 429 | 18.58 | 18.54 |
| 2007 | 257 | 10.74 | 2760 | 51 | 10.56 | 540 | 19.90 | 19.56 |
| 2008 | 327 | 10.90 | 3567 | 63 | 10.90 | 691 | 19.36 | 19.36 |
| 2009 | 330 | 11.10 | 3659 | 67 | 10.90 | 759 | 20.28 | 20.75 |
| 2010 | 363 | 10.44 | 3934 | 74 | 11.15 | 821 | 20.30 | 20.86 |
| 2011 | 391 | 11.10 | 4338 | 80 | 11.32 | 908 | 20.53 | 20.93 |
| 2012 | 422 | 11.28 | 4758 | 86 | 11.02 | 949 | 20.40 | 19.94 |
| 2013 | 381 | 11.18 | 4265 | 72 | 12.07 | 874 | 19.00 | 20.50 |
| 2014 | 410 | 11.26 | 4611 | 85 | 11.43 | 971 | 20.75 | 21.07 |
| 2015 | 437 | 11.33 | 4955 | 82 | 11.76 | 959 | 18.64 | 19.35 |
| 2016 | 377 | 10.92 | 4113 | 66 | 10.61 | 706 | 17.65 | 17.15 |
| 2017 | 415 | 11.41 | 4841 | 70 | 11.26 | 793 | 16.98 | 16.39 |
| 2018 | 408 | 12.15 | 4960 | 64 | 11.26 | 721 | 15.70 | 14.54 |
| 2019 | 423 | 12.31 | 5200 | 65 | 11.71 | 758 | 15.33 | 14.58 |
| 2020 | 561 | 12.1 | 6786 | 74 | 11.40 | 843 | 13.19 | 12.42 |
| 2021 | 503 | 12.48 | 6274 | 70 | 11.37 | 798 | 13.97 | 12.72 |
| 2022 | 585 | 12.33 | 7211 | 75 | 11.15 | 833 | 12.77 | 11.56 |
| 2023 | 567 | 13.41 | 7594 | 1 | 8,81 | 13 | 0.26 | 0,17 |
| Average | 396 | 11.39 | 4593 | 64 | 10.99 | 719 | 16.96 | 16.79 |
| maximum | 585 | 13.41 | 7594 | 86 | 12.07 | 971 | 20.75 | 21.07 |
| minimum | 220 | 10.27 | 2313 | 1 | 8.82 | 13 | 0.26 | 0.17 |

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

**Table (2) the general time trend equation for Production Indicators for the Potatoes Crop in Egypt and Al Behera Governorate During the period (2004-2023)**

| Item | Equation No. | Item | A | β | R2 | F | Average | Growth rate % |
|---|---|---|---|---|---|---|---|---|
| Egypt | 1 | Area (1000 Fed.) | 228.7844 | 15.95 (10.02)** | 0,85 | 100.453 | 396 | 4.02 |
| | 2 | Yield (Ton/ Fed.) | 10.05 | .0,127 (9.355)** | 0,83 | 87.518 | 11.39 | 1,11 |
| | 3 | Prod. (1000 Ton) | 2127.70 | 234.76 (11.362)** | 0,88 | 129.105 | 4593 | |
| Behera Governorate | 4 | Area (1000 Fed.) | 62.82 | 0.31 (0.169) | 0,002 | 0.029 | 64 | 5.1 |
| | 5 | Yield (Ton/ Fed.) | 10.52 | 0,059 (4.028)** | 0,47 | 16.221 | 11.15 | 0.48 |
| | 6 | Prod. (1000 Ton) | 637.04 | 9.767 (1.484) * | 0,11 | 2.202 | 740 | |

$R^2$ and F refer to the coefficient of determination and the value of F calculated respectively, ** significance level of (0.01).* significance level of (0.05), The numbers inside the parentheses indicate the calculated value of (T) Rate of change = Amount of change/average ×100.

**Source**: Compiled and calculated from **Table 1 data.**

**(3) Total Production:**

The data in Table (1) illustrate that the total production of the Potatoes crop in Al Behera Governorate ranged between a minimum of about 13 thousand tons in 2023 (representing approximately 0.17% of the national total) and a maximum of about 971 thousand tons in 2014 (representing approximately 21.07% of the national total), with an average of about 719 thousand tons.

By estimating the general time trend equation, it was found from equation No. (6) in Table (2) that the total production of the Potatoes crop has taken an increasing general trend that is not statistically significant, as the statistical significance of the estimated model was not proven.

**second: Estimation of the Seasonal Index for the Most Important Climatic Factors Affecting the Winter potatoes Crop in Al Behera Governorate During the Period (2004-2023)**

**(1) Seasonal Index of Maximum Temperatures for Production Months During the Study Period in Behera:**

The maximum temperature is defined as the temperature that each plant can tolerate without showing any symptoms of infection that might lead to its death. It varies according to the type of plant and its different stages as well. (Richard L Snyder, 2005).

The data of Table (3) indicate that the average maximum temperatures for the months of Potatoes production in the winter loop from planting to harvest during the period (2004-2023) amounted to about 22.87 degrees Celsius, reaching a maximum in October by about 29.48 degrees Celsius and an increase of

about 6.61 degrees Celsius from the monthly average and an index of about 128.89%, representing an increase of about 28.89% over the average, while it reached The lowest in January by about 18.85 ° C, a decrease of about 4.02 ° C from the average, and a record number of about 82.41%, representing about 17.59% decrease from the monthly average.

**Table (3) Seasonal Guide to Maximum Temperatures in Behera Governorate during the Period (2004-2023)**

| Months | Monthly average (°C) | Seasonal Guide % |
|---|---|---|
| **October** | 29.48 | 128.89 |
| **November** | 24.93 | 108.98 |
| **December** | 20.85 | 91.16 |
| **January** | 18.85 | 82.41 |
| **February** | 20.18 | 88.22 |
| **March** | 22.95 | 100.33 |
| **Average** | 22.87 | 100 |
| **maximum** | 29.48 | |
| **minimum** | 18.85 | |

**Source**: Central Agency for Public Mobilization and Statistics (CAPMAS), **Statistical Book, Chapter One: Geography and Climate,** various issues.

**(2) The seasonal minimum temperature record for the production months during the study period:**

The minimum temperature directly or indirectly affects plants, as its decrease below the normal rate required for plant growth leads to slow growth, as the chemical processes of food conversion are not stopped. (Bassem Habil, 2022).

The data of Table (4) shows that the average minimum temperatures for the months of Potatoes production from planting to harvest during the period (2004-2023) amounted to about 12.81 degrees Celsius, where the highest degree reached in October by about 19.07 degrees Celsius, an increase of about 6.26 degrees Celsius from the monthly average, and a record number of about 148.81%, representing an increase of about 49% over the average, while the lowest degree reached In January, by about 9.49 ° C, a decrease of about 3.32 ° C from the average, and a record of about 74.09%, representing about 25.94% decrease from the average minimum temperature during the months of winter Potatoes production.

**Table (4) Seasonal Guide to Minimum Temperatures in Behera Governorate during the Period (2004-2023)**

| Months | Monthly average (°C) | Seasonal Guide % |
|---|---|---|
| **October** | 19.07 | 148.81 |
| **November** | 14.99 | 116.97 |
| **December** | 11.44 | 89.31 |
| **January** | 9.49 | 74.09 |
| **February** | 10.16 | 79.33 |
| **March** | 11.72 | 91.49 |

| | | |
|---|---|---|
| **Average** | 12.81 | 100 |
| **maximum** | 19.07 | |
| **minimum** | 9.49 | |

**Source**: Central Agency for Public Mobilization and Statistics (CAPMAS), **Statistical Book, Chapter One: Geography and Climate,** various issues.

**(3) Seasonal relative humidity index for the production months during the study period:**

Humidity significantly affects plant water requirements, which in turn impacts crop growth, due to the plants' high need for water present in the soil. The role of humidity in crop distribution is evident, as evidenced by the presence of plants that thrive at relatively low humidity levels, while others thrive at high humidity levels. (Qandil and Sharif, 2014).

**Table (5) Seasonal Guide to Relative Humidity Degrees in Behera Governorate during the Period (2004-2023)**

| Months | Monthly average (%) | Seasonal Guide % |
|---|---|---|
| **October** | 63.45 | 99.17 |
| **November** | 64.85 | 101.35 |
| **December** | 65.85 | 102.92 |
| **January** | 64.30 | 100.49 |
| **February** | 63.35 | 99.01 |
| **March** | 62.10 | 97.06 |
| **Average** | 63.98 | 100 |
| **maximum** | 65.85 | |
| **minimum** | 62.10 | |

**Source**: Central Agency for Public Mobilization and Statistics (CAPMAS), **Statistical Book, Chapter One: Geography and Climate,** various issues.

From the data in Table No. 5, it was found that the average relative humidity for the months of Potatoes production from planting to harvest during the period (2004-2023) amounted to about 63.98%, where the highest percentage in December was about 65.85%, an increase of 2.22% over the monthly average, and the index for the same month reached about 103.53%, representing an increase of about 3.53% over the monthly average humidity, while the lowest percentage in March was about 62.10%, equivalent to about 1.88% from the monthly average, and the index reached about 97.06%, representing about 2.94% decrease from the average relative humidity during the production months.

**(4) Seasonal rainfall index for the production months during the study period:**

Each agricultural crop has its own water requirements, available directly or indirectly. Rainfall is an important factor in determining crop cultivation areas. The importance of rainfall for any crop is determined by the amount of water falling and its distribution during the growing season. **(**Qandil and Sharif, 2014).

The data in Table 6 indicate that the average rainfall for the productive months of the wheat crop, from germination to harvest during the period (2004-2023), amounted to about 10.70 mm, reaching its

maximum in January with an amount of about 17.64 mm and an increase of 6.94 mm over the average months of production, and the index for the month of January reached about 146.87%, representing an increase of about 46.87% over the average monthly rainfall, and the lowest percentage In October, about 3.47 mm, representing a decrease of 7.23 mm from the monthly average, and a record number of about 32.46%, representing about 67.54% decrease from the average amount of rainfall during the production months.

**Table (7) Seasonal Guide to the Amounts of rainfall in Behera Governorate during the Period (2004-2023)**

| Months | Monthly average (mm) | Seasonal Guide % |
|---|---|---|
| **October** | 3.47 | 32.46 |
| **November** | 10.28 | 96.13 |
| **December** | 12.52 | 117.04 |
| **January** | 17.64 | 164.87 |
| **February** | 11.69 | 109.24 |
| **March** | 8.59 | 80.26 |
| **Average** | 10.70 | 100 |
| **maximum** | 17.64 | |
| **minimum** | 3.47 | |

**World Bank Group** the Climate Change Knowledge Portal (CCKP), Climate Data for Egypt (2024).

**third: Standard assessment of the impact of climate variables on Potatoes crop productivity in Al Behera Governorate:**

Environmental factors play a significant role throughout the life cycle of wheat plants, both positively and negatively. Therefore, this part of the study will address the extent of the impact of various climate changes, including maximum and minimum temperatures, relative humidity, and rainfall, during the period during which the crop remains in the ground, from the planting month (November) until the harvest month (May). This will be achieved using a stepwise multi-stage logarithmic model (stepwise) for both the maximum and minimum temperature, while the full model (enter) was used for the amount of rainfall and relative humidity.

**(1) Estimation of the effect of maximum temperature on the yield of winter Potatoes crop:**

The data presented in Table No. (7), Equation No. (1), indicates the relationship between the yield per feddan of winter Potatoes crop in Al Behera Governorate and the maximum temperature during the period (2004-2023). Where it was found that the variable (S5), which represents the month of February, has a statistically significant adverse effect on the productivity of the acre of potatoes, as the rise in the maximum temperature by one degree Celsius will lead to a decrease in the productivity of the crop by about 0.88 tons per acre, where the significance of the variable was proven at the probability level of 5%, and it was also shown from the data of the same equation that the variable (Q6), which represents the month of March, that it has a statistically significant direct effect on the productivity of the acre, as The increase in the minimum temperature by one degree Celsius will lead to a rise in the productivity of the crop by about 0.85 tons per acre, and the significance of the variable has been proven at the probability level of 5%, while the significance of the rest of the variables has not been proven, and the coefficient of

determination is about 0.56, which shows that 56% of the changes in the productivity of the Potatoes crop are due to changes in the maximum temperature during those months.

**(2) Estimating the Effect of Minimum Temperature on Winter Potatoes Yield:**

The data presented in Table No. (8), Equation No. (2), illustrates the relationship between the yield per feddan of Potatoes crop in Al Behera Governorate and the minimum temperature during the period (2004-2024). Where it was found that there were inverse and direct relationships between the minimum temperature and the production months, while no statistically significant effect was proven between the minimum temperature of the Potatoes planting months and the acre productivity during that period.

**Table (7) Estimating the impact of minimum temperature on wheat crop productivity in Al Behera Governorate during the Period (2004-2023)**

| Equation No. | Item | Equation | R2 | F |
|---|---|---|---|---|
| 1 | Maximum Temp. | Log Y^ = 0.893 - 0,061 Log X1 + 0,019 Log X2- 0,088 Log X3 + 0,239 Log X4- 0,879 Log X5 + 0,853 Log X6<br>. (-0,050) (-0,025) (-1,181) (0,265) (-1,891)* (2,951)* | 0,56 | 2,75* |
| 2 | Minimum Temp. | Log Y^ = 1.075+ 0,142 Log X1 + 0,112 Log X2 - 0,194 Log X3 - 0,305 Log X4 + 0,347 Log X5 - 0,197 Log X6<br>(0,202) (0,312) (-0,607) (-1,326) (1,143) (-0,755) | 0,17 | 0,463 |
| 3 | Relative humidity | Log Y^ = 0.072 + 0.530 Log X6<br>(3.195)** | 0,36 | 10,209** |
| 4 | Rainfall amount | Log Y^ = 1.061+ 0,015 Log X1 + 0,030 Log X2 - 0,011 Log X3 + 0,003 Log X4 -0,045 Log X5 - 0,015 Log X6<br>(1,547) (2,482)* (-0,615) (0,164) (-1,795)* (-1,261) | 0,51 | 2,218 |

where: y^: productivity in tons/acre, (x1): October, (x2): November, (x3): December, (x4): January, (x5): February, (x6): March,

*: Significant at the level of (0.05), the value in parentheses indicates the value of (T), (R2) the coefficient of determination.

**Source:**

1- **Table No. (1)**

2- Central Agency for Public Mobilization and Statistics (CAPMAS), **Statistical Book, Chapter One: Geography and Climate**, various issues.

3- **World Bank Group** the Climate Change Knowledge Portal (CCKP), Climate Data for Egypt (2024).

**(3) Estimation of the effect of relative humidity on the productivity of the winter Potatoes crop:**

Equation (3) in Table (7) shows that the value of the modified coefficient of determination (**R2**) amounted to about 0.36, which shows that the interpreted production elements are responsible for only about 36% of the changes in the production quantity of the Potatoes crop in Behera Governorate, and the significance of the variable (x6), which represents the month of March, has been proven to be significant, as it was found that its relationship has a statistically significant direct effect with productivity, As the increase in the percentage of moisture by one unit will lead to an increase in the yield of the crop by about 0.53 tons per acre, while the significance of the rest of the variables has not been proven, and the significance of the model as a whole has been proven at the level of (0.001).

**(4) Estimating the Impact of Rainfall on productivity of the winter Potatoes crop:**

Equation No. (4) in Table (7) indicates that the value of the adjusted coefficient of determination ($\mathbf{R^2}$) amounted to about 0.51, which shows that the explained production elements are responsible for only about 51% of the changes in the acre productivity of the Potatoes crop in Behera Governorate, and the significance of the variable (x2), which represents the month of November, has been proven to be significant, as it was found that its relationship has a statistically significant direct effect with the dependent variable, As the increase in the amount of rain by about 0.030 mm will lead to an increase in the acre productivity of the crop by about 0.03 tons per acre, as proved by the significance of the variable (x5), which represents the month of February, where it was found that its relationship has a statistically significant adverse effect with the dependent variable, as increasing the amount of rain by about 0.045 mm will lead to a decrease in the acre productivity of the crop by about 0.045 tons per acre, While the rest of the variables were not proven significant, noting that the average rainfall for the months of November and February during the study period was about 10.78 and 11.69 mm, respectively.

**Third: Econometric Estimation of the Impact of Climatic Elements on the Total Production of Winter Potatoes Crop in Behera Governorate:**

Potatoes plant The weather plant is cold needs in the first stages of its growth during the first two months of its life to a fairly warm atmosphere with a temperature ranging from 25 to 20 degrees Celsius and a relatively long day in order to encourage the plant to form a suitable vegetative and root group, then followed by an atmosphere that tends to cool from 15 to 18 degrees Celsius and a short day during the period of formation and growth of new tubers, where the short photoperiod and low temperature help to speed up the process of Pour the tubers and thus increase the amount of the total plant yield (Ministry of Agriculture and Land Reclamation, 2022).

Where it was found that one of the best images to estimate this is the multiple logarithmic model during the period (2004-2023), and equation No. (1) indicates a statistically significant relationship between the total Potatoes production and the maximum temperature, as its increase by 1% will lead to an increase in total production by 6.58 tons, The equation also indicates a statistically significant relationship between the total Potatoes production and relative humidity, as an increase in relative humidity by 1% will lead to an increase in total production by 3,347 tons, and it was also found that there is an inverse relationship with the minimum temperature and total production and direct with rainfall, but without significant, this has reached the coefficient of determination of the model About 0.42, which means that the previous

variables explain about 42% of the changes in the total production of the Potatoes crop, and the statistical significance of the model was fixed at the level of (0.05).

**Equation No. (1)**

**Log Y^ (Yield) = -9.355 + 6.580 Log X1 (Max. Temp.) - 0.179 Log X2 (Min. Temp.) + 3.347 Log X3 (Relative Humidity) + 0.322 Log X4 (Rainfall)**

*(2.232) (-0.132) (2.904) * (1.286)
F = (2.722) * $R^2$ = (0.65)

**Where Y^:** Production in tons (X1): Maximum temperature, (X2): Minimum temperature, (X3): Relative humidity, (X4): Rainfall amount

*: Significant at the (0.05) level The value in parentheses indicates the (t) value

**Source:**

1- **World Bank Group** the Climate Change Knowledge Portal (CCKP) Climate Data for Egypt (2024).

2- Central Agency for Public Mobilization and Statistics (CAPMAS), **Statistical Book, Chapter One: Geography and Climate,** various issues.

## 4. Conclusion

**Based on the research results, we recommend the following:**

1-Providing climate information by the General Authority of Meteorology to farmers and developing awareness methods.

2- Reconsider the dates of planting potatoes to suit climatic conditions.

3- Providing farmers with information and guidance to confront climate change by activating the role of agricultural extension.

4- Activating the role of agricultural extension in providing farmers with information and guidance to address climatic change.

5- Working to develop and derive new varieties that adapt to changing climatic conditions.

6- Providing in-kind and cash support to farmers to face climate changes that affect Potatoes production in Behera Governorate.

## 5. References

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