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An Economic Study of the Impact of Climate Change on the Rice Productivity in Egypt

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ABSTRACT: Achieving of the food security is one of the most important economic problems that threaten economic and social development in Egypt, through the imbalance between supply and demand, thus the occurrence of a food gap due to the increase in food demand as a result of the increase in the population growth rate, in addition to the inability to increase agricultural production to meet the increases demand of food. The inability of production to meet the growing needs leads to increases the imports of crops and food commodities, and an increase in the deficit in the Egyptian trade and agricultural balance. The cereal crops are the most important strategic crops for achieving food security and meeting the needs of the population in terms of demand for them. The agricultural production of these crops is affected by climatic changes by negatively affect of agricultural production (CAPMAS). In this paper i examine how the Climate Change affected on the rice productivity in Egypt, with the aim of determining the extent to which productivity has changed due to climate change in Egypt, using the Autoregressive Distributed lagged Model (ARDL), where it was found that there is an inverse relationship between climate changes and the rice productivity. The results indicates that a similar negative impact of the maximum temperature change on the rice productivity in the long term, which is consistent with an economic theory.

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Literature review: Over the past years, many studies utilized the impact of climate change on the agricultural production. This section is overviews the recent empirical analyses on the impact of climate change on the agricultural production. The study of (Siyam , Fayyad 2009) studied the impact of climate changes on the conditions of agriculture and food in Egypt, this study aims to assess the impact of climate changes on the future food situation in 2030 in Egypt, represented in the size and value of the food gap and self-sufficiency rates, where climate changes affect agriculture and food through the impact of carbon emissions on crop productivity as well as sea level rise on the delta's sinking. The study recommended the need to adopt appropriate strategies to combat the rise in sea levels and prevent erosion of the northern shores of the delta, as the cost of these measures is estimated at about $300 million.

(AlBaidi , Hammouda 2015) studied the climate changes and their impact on agricultural output in Libya for the period (1980-2010), the study showed that climate change has a strong impact on agricultural production, and therefore on food supplies and food security. The study used Granger's pairwise causality on time series data to examine the causal relationship between climatic conditions and annual production of important crops in Libya during the period (1980-2010), where the study showed that the climatic variables, namely precipitation and temperature, have a clear effect on the crops of wheat, barley, onions, watermelons, tomatoes and potatoes. It was also shown that there is a two-way causal relationship between the trend of temperature and potato production, and a one-way causal relationship between temperature and the production of watermelon and wheat, while there was no causal relationship between temperature and production of barley, onions and tomatoes. The results also showed a one-way causal relationship between precipitation and potato and wheat production, and a two-way relationship between rainfall and watermelon production. There was no directional cause between precipitation and barley or tomato production. The study recommended that the Libyan authorities should pay more attention to cultivating crop varieties that are resistant to drought and heat, and focus on developing these varieties.

(Zein 2016) studied of the effects of climate changes on grain production in Sudan during the period (2005-2015). The study dealt with the study of the effects of climatic changes on grain production in Sudan, to show the effect of some climate elements in Sudan, which limit the increase in production and productivity. Data were used to analyze the average annual precipitation for the period (2005-2015). The study used the statistical and analytical method in analyzing the climatic, productivity and productivity data, where the correlation coefficient was used to show the standard questionnaire relationships between the variables, and the study showed that both corn and millet crops were affected by climate changes. The study recommended that agricultural research stations should be equipped with meteorological stations in agricultural projects to know weather conditions in order to assist in the largest production of agricultural crops. It also recommended educating farmers and training them on different climatic conditions.

(Bahloul et al. 2019) estimated the economic effects of climate change on the wheat crop in Egypt, where the study aimed to measure the economic effects of climate change on the wheat crop in the regions and governorates of Egypt. The study used the Ricardo model to assess the economic effects of climate change on the net yield of agricultural crops. The main results were as follows: Future climate changes will have negative effects on agriculture and the food system in general and on most agricultural crops in particular. The results also indicated an increase in the average net production of the wheat crop, with a significant growth rate and an estimated increase of 65.20 pounds per feddan during the period (2005-2017). The study also showed that there are negative effects of increasing the minimum temperature and relative and relative humidity (except for the high humidity, which is about 5%, and the positive effect on the net yield of the wheat crop), while the effects were positive, with an increase in the decrease in the minimum and relative temperatures and relative humidity. The study recommended the necessity of developing new varieties that bear high temperatures and high relative humidity, as well as cultivating suitable varieties in suitable climatic regions, educating and training farmers on how to adapt and grow wheat crops under the current and expected climatic conditions in terms of climate, and the use of appropriate planting dates, varieties and agricultural processes. Use of appropriate planting dates, varieties and different agricultural processes to increase the yield and yield of wheat crop in Egypt.

(Zaher et al. 2019) studied the impact of climate changes on the production of some field crops, the study aims to study the factors affecting agricultural production of the most important crops under study, whether they are economic or environmental variables, and then to identify the fluctuation of agricultural production for the most important strategic crops that its production is affected by climate changes, as the study dealt with the problem of the negative impact of the phenomenon of climate change and environmental pollution on agricultural production in light of contemporary environmental and economic changes. The study aimed to identify the most important environmental and economic factors responsible for bringing about changes in agricultural production. It was found from the results that the most important factors affecting wheat production are the cultivated area of the wheat crop, average minimum temperature, and average maximum temperature. It was also found that there was a direct correlation between the quantity of wheat production and the cultivated area of wheat crop. Where it was shown that there was an increase of 90% in the total wheat production by increasing the cultivated area of wheat by 10%, and it was shown that there was a positive correlation between the amount of wheat production and the average minimum temperature, as the results showed an increase in the total production of the wheat crop by about 10.4% with an increase in the average temperature. The minimum temperature increased by 10%, and an inverse relationship was found between the amount of wheat crop production and the average maximum temperature, as the results indicated a decrease in the total wheat production, as an increase in bone temperature by 10% led to a decrease in agricultural production by 27% during the study period.

(Rizk Allah 2020) studied the impact of climate changes on the productivity of agricultural crops in Egypt, and the study showed that there are very few studies that deal with the relationship between climate changes and their impact on the productivity of agricultural crops in developing countries, especially Egypt. Where the study aimed to measure the effect of climatic changes represented in temperature and precipitation on the productivity of Egyptian agricultural crops (wheat and corn) in the long and short term during the period (1981-2014) according to the division of the governorates producing agricultural crops in three regions: Upper Egypt, Middle Egypt, and Lower Egypt. The study used the method of modern econometric techniques of fully modified average OLS (FMOLS) to estimate the trend of co-integration of data to derive long-term estimates of the impacts of climate change on productivity on wheat and maize crops. The study showed that there is a long-term significant relationship between the average temperatures and the productivity of corn and wheat crops alike, and that the temperature greatly affects the productivity of the two crops in the long term and not in the short term, and the rainfall rate did not have a significant effect on the long and the short term.

(AlJubouri et al. 2020) studied the impact of climate change on food security for a sample of Arab regions for the period (2005-2015), where the study showed that climate change that the world is witnessing is one of the most important challenges facing developed and developing (Arab) countries alike. Because of the accompanying effects and repercussions on various fields, and the sector that is most sensitive to these changes is the agricultural (food) sector. Agricultural and food production in the Arab region is negatively affected by climate change, especially in countries that are exposed to climate fluctuations (drought, desertification and floods) and suffer from low income and widespread hunger and poverty. The study showed that the impact of climate fluctuations appeared in the form of fluctuations in production, a widening of the food gap, and an increase in dependence on the outside world in providing foodstuffs in the Arab region for the period (2005-2015). This is due to a number of reasons, including global warming, increased carbon dioxide emissions, higher temperatures, and increased evaporation, which directly and indirectly affects agricultural food production. The study also showed that climate change has direct negative nutritional effects, including an imbalance in the quantities and components of consumption, as well as on the income level of individuals who depend on agriculture to obtain it, which is often intended for consumption, which exposes them to the risk of not being able to deal with this type of fluctuation.

(ElBadry 2022) studied the impact of climate changes on the productivity of the most important grain crops using the (ARDL) model, with the aim of determining the extent to which productivity changes the most important grain crops with climate change, and to identify the extent to which the actual reality corresponds to the economic theory that emphasizes that temperature change it leads to a change in agricultural production, and the Autoregressive distributed lagged model (ARDL) was used, as it was found that there is an inverse relationship between climate changes and the productivity of the most important grain crops, a relationship that is consistent with economic logic, and it was also shown that there is a long-term equilibrium relationship between climate changes and the productivity of the most important grain crops, where it was found that there is a negative effect of the change in the maximum temperature on the productivity of the most important grain crops in the long term, that is, an increase in the maximum temperatures by 1% leads to a decrease in productivity by about 0.15%, 0.07%, 0.15% for wheat, corn, and rice crops, respectively. It is consistent with economic theory. The study also showed that the value of the error correction coefficient was about (-0.531), (0.650), (-0.532) for wheat, corn, and rice crops, respectively, which indicates that when the productivity of the most important grain crops deviates from the equilibrium value during the short term, the speed of its return to the equilibrium value in the long term is about 53.1%, 65%, and 53.2% for the crops of wheat, corn, and rice, respectively, from the imbalance, during a unit of time until it reaches equilibrium after about 1.6 years, 1.4 years, 1.6 years for the crops of wheat, corn , rice, respectively, to return to the long-term equilibrium position. The study recommended the need to choose genetically improved varieties and seeds with high productivity that can withstand climate changes, drought and humidity, uses the modern technology to store grains to reduce the storage losses, relying on early warning systems for sudden climatic changes to achieve food security stability, Expansion of green economy projects and environmentally friendly projects. Develop economic policies that take into account adaptation to climate change, and optimal use of available water resources.

This research aims to study the impact of climate changes on the productivity of rice crop in Egypt during the period (2005-2021), by using the Autoregressive Distributed lagged Model (ARDL) to ensure the existence of a long-term co-integration relationship between climate changes and rice productivity, to identify the extent to production changes with climate changes through the study of: Develop the rice productivity in Egypt during the period (2005-2021). Evaluate the temperatures, precipitation and humidity levels during the study period. Estimate the impact of climate change on rice productivity in Egypt by using the Autoregressive Distributed lagged Model (ARDL).This research relied on the descriptive and quantitative statistical analysis method, where some statistical analytical methods were used, such as time series analysis, and the Autoregressive Distributed lagged Model (ARDL) (Pesaran, et al. 2001). The research relied on secondary data published in many official agencies such as the Ministry of Agriculture and Land Reclamation, the Department of Climate Research, the website of the Central Agency for Public Mobilization and Statistics (CAPMAS), (The General Authority for Meteorology), and some research, studies and scientific books related to the subject of the research were used.

MATERIAL AND METHODS

The research relied on the use of statistical analysis and econometrics tools, where the unit root test (AlSawai, K. 2012) was used to ensure the stability of the time series by using the Augmented Dickey Fuller Test, the Bounds test to identify the extent of the existence of co-integration between variables. Normality Test, Stability test, Autoregressive Distributed lagged Model (ARDL).

Autoregressive Distributed lagged Model (ARDL):

The research uses the Autoregressive Distributed lagged methodology (ARDL) (AlYousef, N. A.R.2013; AlSawai, K. 2012) developed by (Pesaran, et al. 2001), where the methodology is distinguished by that it does not require that the time series be integrated of the same degree, as Pesaran believes that the (Pounds test) in the (ARDL) can be applied if the time series is stable at the zero level I(0) or integrated of the first degree I(1), and the only condition for applying this test is that the time series should not be integrated of the second degree I(2), and it can also be used in the case of short time series, compared to the co-integration test such as the Granger method (Engle-Granger 1987) or the co-integration test (Johannsen Contegration Test (VAR) model 1999).

Also, the (ARDL) can be applied in the case of the small-sized samples, unlike the co-integration test, which requires that the sample size be large. It is also possible to obtain estimates for the long and short term together at the same time in one equation instead of two separate equations, and it gives the best results for the parameters in the long term, it is also possible to rely on (Diagnostic tests) to determine the validity of the estimated model. The (ARDL) can separate the effect of the short term over the long term, determining the size of the influence of each of the independent variables on the dependent variable, and estimating the parameters of the independent variables in the long and short terms.

To test the equilibrium relationship between the variables in the (ARDL) model which were achieved, in the unrestricted error correction model (UCEM), using the Bounds test, where the (ARDL) model includes testing a long-term equilibrium relationship between the variables of the model. The existence of this relationship, then the parameters of the long and short term are estimated, through the (F) statistic using the (WALD Test), where the null hypothesis is tested that there is no co-integration between the variables of the model:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_n$

While the alternative hypothesis is the existence of co-integration between the model variables in the long run:

H_0: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_n$

The Autoregressive distributed lagged model (ARDL) (AlSawai, K. 2012; AlYousef, N. A.R.2013) in:

1- Testing the stability of the time series using the Unit Root Test.
2- Cointegration test using (Bounds Test).
3- Estimating the long-term model using (ARDL).
4- Evaluation of the error correction model (ECM).
5- Residuals test for the stability of the model.

Where the (ARDL) model consists of: (p, q_1, q_2……q_n) of a dependent variable and a number of independent explanatory variables (X_1, X_2……X_n) as:

C = Fixed term
D_1 = First degree differences. K = Number of independent variables.
P = Lagged period of the dependent variable Y_1
q_1, q_2……q_n = period of slowing down of explanatory variables.
a_1, a_2……a_n = long-term transactions.
β1, β2…… βn = Short-term transactions.

RESULTS AND DISCUSSION

First: Development of the study variables during the period (2005-2021):

A study of rice productivity in Egypt (CAPMAS 2022) showed that it ranged between a minimum of about 3.79 tons and a maximum of about 4.24 tons during the study period. By estimating the time trend equation for the development of rice productivity in Egypt, it was found a statistically significant decreasing trend, by amounting about 0.021 tons, representing about 0.52% of the average for the study period (2005-2021) of about 4.0 tons. While by estimating the time trend equation for the development of the maximum temperature in Egypt, it was found a statistically significant increasing trend of about 0.104 **C°**, which represents about 0.35% of the average study period of about 29.41 **C°**, while it was found a statistically significant increasing trend for the development of the minimum temperature in Egypt by about 0.175 degrees Celsius, which represents about 1.03% of the study period average of about 16.98 degrees Celsius. While by estimating the time trend equation for the relative humidity in Egypt, it was found a statistically significant decreasing amounted to about 0.714%, representing about 1.4% of the study period average of about 50.97%, while it turns out for the evolution of the amount of precipitation in Egypt, that it was found a statistically significant decreasing trend of about 0.174 mm, representing about 5.55 % of the study period average of about 3.14 mm **-** Table (1).

Table (1): Equations of the trend for the development of rice productivity, temperatures, amount of rain and relative humidity during the period (2005-2021)

Variable	Equation	Average	Growth	R^2	F
Rice productivity (tons)	$\hat{Y}_t$= 4.190- 0.021 T *(-5.55)***	4.00	-0.52	0.672	30.8**
Max. Temperature (C°)	$\hat{Y}_t$= 28.46+ 0.104 T *(2.33)**	29.41	0.35	0.266	5.4*
Min. Temperature (C°)	$\hat{Y}_t$= 15.39+ 0.175 T *(4.32)***	16.98	1.03	0.554	18.6**
Relative humidity (%)	$\hat{Y}_t$= 57.41- 0.714 T *(-4.69)***	50.97	-1.40	0.595	22.0**
Amount of rain (mm)	$\hat{Y}_t$= 4.721- 0.174 T *(-3.15)***	3.14	-5.55	0.398	9.9**

**Significance at the 0.01 level. *Significant at the 0.05 level.
Source: Collected and calculated from the website of (CAPMAS): www.capmas.gov.eg

Second: Estimation of the Autoregressive Distributed Lagged Model (ARDL).

In order to estimate the model of the impact of climate change on rice productivity in Egypt by using the (ARDL) method, the conditions for the stability of the time series (Augmented Dickey Fuller test) must be met (Tawil, A.,et al. 2021; Zahra, Shoman 2013) , whether stable at the zero level I(0) or integrated of the first level I(1), and to ensure the stability of the time series in time, the unit root test was performed using the Augmented Dickey Fuller Test, where it was found that some of the model variables It is stable at the zero level with a degree of 95% confidence and does not have a root unit (Mostafa , Elbadry 2015), while it was found that some of them are unstable at the zero level and have a root unit so the first difference was taken, as it was found after taking the first difference that the value of (t) calculated is greater than its tabular value at the level of significance 0.05, which means the absence of a unit root and the stability of the time series, which necessitates the use of the Autoregressive Distributed Lagged Model (ARDL) presented by (Pesaran, et al. 2001) Table(2) .

Table No. (2): Results of the Dickey Fuller test Augmented Dickey Fuller (ADF)

Variable	Difference	With Constant	With constant and trend	Without constant and trend	degrees of integration
Rice productivity (tons)	**Zero**	-1.806	-2.674	-0.137	I(1)
	Frist	-5.059**	-5.681**	-5.191**	
Max. Temperature (°C)	**Zero**	-2.845	-5.351**	1.168	I(0)
	Frist	-4.844**	-4.706**	-4.622**	
Min. Temperature (°C)	**Zero**	-1.863	-4.650**	1.504	I(0)
	Frist	-4.574**	-4.390**	-7.375**	
Relative humidity (%)	**Zero**	-1.295	-2.871	-1.106	I(1)
	Frist	-6.291**	-6.70**	-6.154**	
Amount of rain (mm)	**Zero**	-3.202*	-3.390	-0.946	I(0)
	Frist	-4.778**	-4.603**	-4.912**	

**Significance at the 0.01 level. *Significant at the 0.05 level.

Source: Collected and calculated from: Data of Table (1) by using the E-views 10.

The ARDL models consist of one dependent variable and a numbers of explanatory independent variables (X_1, X_2……X_n):

a = constant
Y = Rice yield (ton)
X_1= Max. temperature
X_2= Min. temperature
X_3 =Humidity rate (%)
X_4= Amount of rain

Rice Yield Model

Y= $a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4$

After ensuring the stability and integrity of the time series, whether at the zero degree or the first degree, the (ARDL) model is estimated through the following steps:

1- Bounds Test (AlSawai, K. 2012):

The bounds test was conducted to find out whether or not there is co-integration between the variables of the model. If the calculated (F) value is greater than the upper limit of the critical values, then the null hypothesis is rejected, which states that there is no long-term equilibrium relationship between the variables, and the alternative hypothesis is accepted that there is a relationship, by the presence of Co-integration between the variables of the study, but if the value of (F) calculated is less than the min. critical values, then the alternative hypothesis is rejected and the null hypothesis is accepted because there is no equilibrium relationship in the long term, there is co-integration between the variables of the study according to the Bounds Test approach it was found from the limits test results that the calculated (F) value was about 24.2 for the rice productivity model, which is greater than the upper limit of the critical values of the limits, which means rejecting the null hypothesis and accepting the alternative hypothesis of the existence of a long-term equilibrium relationship between the variables of the model at the level of significance 5% - Table (3).

Table (3): Results of the (F Bounds Test

F	Sig. F	Min. level I(0)	Max. level I(1)
24.2	1%	3.74	5.06
	5%	2.86	4.01
	10%	2.45	3.52

Source: Collected and calculated from: Data of Table (1) by using the E-views 10.

Second: Estimating the equilibrium relationship in the long term (Darwish, Abdelkader 2013):

It was concluded that there is a long-term relationship between the variables of the study, and a maximum number of slowing periods was determined, and therefore the (ARDL) model (3,0,2,2,2) was chosen for the rice crop model, as it is considered the best model for estimating the equilibrium relationship in the long term.

The results of estimating the impact of climate change on the rice productivity in Egypt using Autoregressive Distributed Lagged Model (ARDL) during the study period showed that there is a long-term inverse relationship between the dependent variable (rice productivity) and the independent variable (maximum temperature), it meaning that a decrease in the maximum temperature by 1% leads to an increase in the rice productivity by about 0.17%, as it was found that there is a Positive relationship in the long-term between the rice productivity and both the minimum temperature and the relative humidity, it meaning that an increase in both the minimum temperature and the relative humidity, by 1% leads to an increase in the rice productivity by about 0.07% and 0.03%, respectively. It was also shown that there is a Positive relationship in the long-term between the rice productivity and the amount of rainfall, that is meaning an increase in the amount of rainfall by 1% leads to an increase in the rice productivity by about 0.04%, and this is consistent with the economic theory.

It was also found that the determination coefficient was about 0.991, which means that the estimated model variables explain about 99.1% of the fluctuations in rice productivity due to the change in the maximum temperature, the minimum temperature, the relative humidity and the amount of precipitation, while the rest of the fluctuations are due to other factors, was not included in the model. It was also shown through the calculated F value that it amounted to about 105 at a significant level of 0.01, then the significance of the estimated the whole model, this means that the model was accepted from a statistical theory.

The significance of the error correction coefficient and its negative sign, as it reached about (-0.534) at a significant level of 0.01, this indicates the existence of a co-integration relationship between the variables explaining the rice productivity. That is mean, when rice productivity deviates from the equilibrium value in the short term, it quickly returns to its equilibrium value in the long term, and about 53.2% of the imbalance is corrected during period (t) until it reaches equilibrium again.

Table (4): Results of Estimating the ARDL model in the long term and the error correction in the short term

long term model	Error correction in the short term
$Y_1 = -0.1752X_1 + 0.0651X_2 + 0.0278X_3 + 0.0346X_4$ $R^2=0.991$ $F= 105^{**}$	-0.534^{**}

**Significance at the 0.01 level. *Significant at the 0.05 level.

Source: Calculated from data of table (1) by using the SPSS program.

Third: Diagnostics Test (Azouzi , Amiri 2019)

Diagnostic tests are used to judge the suitability of the model used in measuring the estimated elasticities in the long term, to ensure the quality of the model used in the analysis and not to include errors and measurement problems:

1- **The Autocorrelation test between errors (LM Test)** (Salami , Salami 2020)

This test is used to detect the possibility of a serial correlation between errors, in order to find out the possibility of accepting the null hypothesis that there is no problem of serial autocorrelation between the parameters of the estimated models.Where, it was found that the significant value of (F) was about 0.164 for the rice model, which is greater than the significant level of 0.05,therefore the null hypothesis is accepted that there is no serial autocorrelation problem between the errors of the estimated model parameters - Table (5).

Table (5): Results of examining the model residuals

Normality Test ***Jarque-Bera Test***	***Heteroskedasticity ARCH Test***	**Serial Correlation *(LM Test)*** **Breusch-Godfrey Serial Correlation**
Jarque-Bera *= 1.199* *Prob.= 0.549*	***F*** *= 0.937* *Prob.(1,15)= 0.346*	***F*** *= 5.11* *Prob.(2,2)= 0.166*

Source: Collected and calculated from: Data of Table (1) by using the E-views 10.

2- Testing the Autoregressive condintional Heteroskedasticity (ARCH Test) (Mostafa , Elbadry 2015)

This test is used to detect the problem of instability of the variance of the error limit as it depends on the Lagrangian multiplier, as it was found that the significant value of (F) reached about 0.349, which it greater than the significant level of 0.05, and therefore we reject the null hypothesis and accept the alternative hypothesis that there is no existence the stability of the variance of the error limit for the estimated model parameters - Table (5).

3- Normality Test (AlYousef, N. A.R.2013)

This test is used to detect the normal distribution of the rest of the estimated models, as it depends on the Jarque-Bera test, as it was shown from Table (5) that the Jarque-Bera statistic reached about 1.199, which is less than the tabular value of the Kai distribution of the rice productivity model with degrees of freedom 18, also the critical probability ratio is greater than of the significance ratio of 0.05, then, we accept the null hypothesis H_0 that the residuals are distributed normally, in addition to that the skewness coefficient was about 0.611, so the probability distribution of the residuals of the estimated model is moderate, which indicates the symmetry of the probabilistic distribution of the residuals of the estimated model, where it turns out that the probability distribution curve of the estimated model is positive, which slightly to the right - Figure (1).

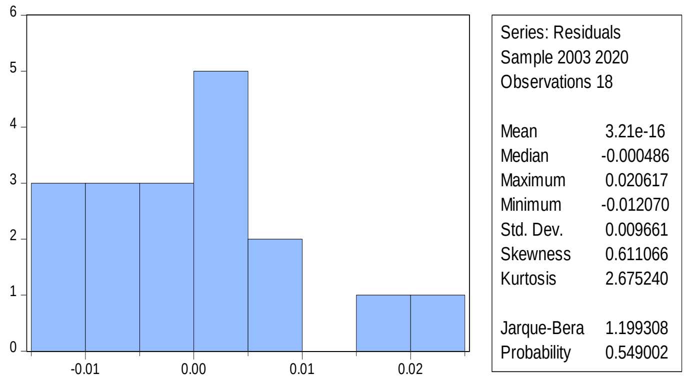

Fig.(1): Normal distribution test for the residues of the Rice productivity Model

Source: By using the E-views 10

4- Stability Test: (Dickey , Fuller 1979**)** (AlSawai, K. 2012)

The cumulative sum squares test (Cumulative Sum Squares) is used to detect the presence of any structural changes and to indicate the stability and consistency of the parameters of the long-term models with the short-term parameters, to verify the structural stability of the estimated coefficients to correct the error of the Autoregressive Distributed Lagged Model (ARDL), if the graph falls within the critical limits at a significant level of 0.05, it means that the model parameters are stable throughout the study period - Figures (2:3). It was found from the figures are structurally stable over the study period, and we also notice a harmony in the model between the results of error correction in the long and short term, as the figures fell within the critical limits at a significant level of 0.05.

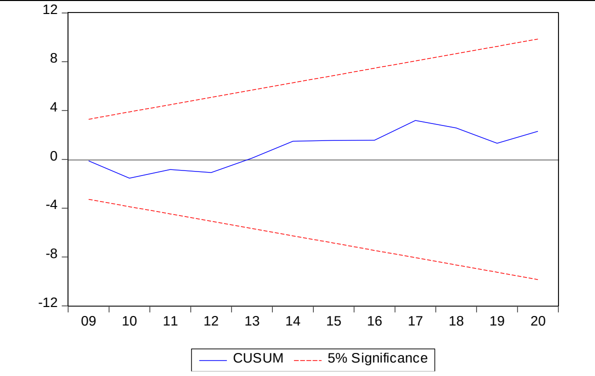

Fig.(2): Stability test of the rice yield model (Residuals cumulative) (Cusum test)

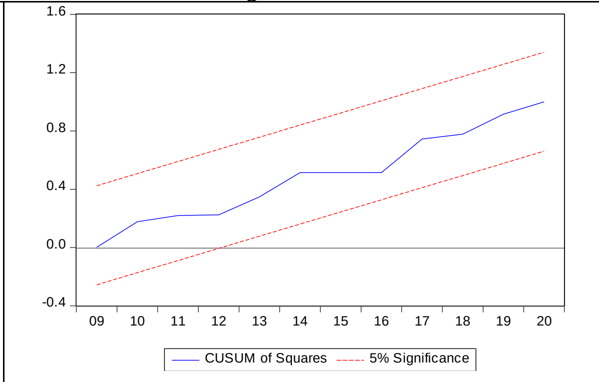

Fig.(3): Stability test of the rice yield model (Residuals square cumulative) (Cusum of Squares test)

Source: By using the E-views 10

CONCLUSION AND RECOMMENDATION

This research deals study the impact of climate changes on the productivity of the rice crop in Egypt during the period (2005-2021), with the aim of determining the extent of the climate change on the rice productivity in Egypt, by using the Autoregressive Distributed lagged Model (ARDL), where it was found that there is an inverse relationship between climate change and the rice productivity, a relationship that is consistent with economic logic, where it was shown that there is a negative impact of the change of maximum temperature on the rice productivity in the long term. That is, an increase in the maximum temperatures by 1% leads to a decrease in rice productivity by about 0.17%, which is consistent with the economic theory. It also shows that there is a long-term equilibrium relationship between climate changes and the rice productivity, as its estimated significance was proven. It was also found that the value of the error correction coefficient was about (-0.534), which indicates that when the rice productivity deviates from the value of equilibrium during the short term, the speed of it's to return the value of equilibrium in the long term is about 53.4% for from the imbalance, during the unit of time to reach the equilibrium after about 1.62 year to return the long term of the equilibrium position. The research recommended of choosing genetically improved varieties and seeds with high productivity that can withstand the climate changes, drought and humidity. Use the modern technology for storing the cereals to reduce the losses of storage. Rely on the early warning systems for sudden climatic changes to achieve food security stability. Expand of the green economy projects and environmentally friendly projects. Develop the economic policies that take into account adaptation to climate change. Use the optimal of available water resources.

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