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## THE NEXUS BETWEEN GLOBAL WARMING, ECONOMIC GROWTH, AND CEREAL PRODUCTION IN EGYPT.

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**Abstract** *This study aims to examine the connection between global Warming, economic growth, and cereal Production in Egypt in the period from 1960 – 2022. The data sample consists of temperatures' annual average mean, GDP per capita growth (annual %) and cereal production (metric tons) data from the World Bank's official website. This study employs, the Granger causality test and an augmented autoregressive distributed lag (ARDL) test.*

*The main findings are; a positive significant impact of global warming, on GDP in the short run, while an insignificant impact of global warming on cereal production in the short run, however in the long run global warming has significant & positive impacts on both GDP and cereal Production, the study contributes to the fields of Environment & economy by detecting the influence of global warming on both food production and economy. Based on these results, the study offers significant policy implications such as technology adaptation options that may find beneficial and affordable, climate-smart crop varieties—those resistant to heat and drought—should be made available, improvement of agricultural practices, farmers should be educated and guided, and policies have to modify to more effective in regulating prices.*

**Keywords:** - Global Warming, GDP, Cereal Production, ARDEL

**JEL Codes:** Q10 - Q18 - Q51 - Q56

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## **Introduction:**

Today the impact of global warming, on the world's economy is enormous, currently it is costing the world \$1.6 million per hour, (Zhang, 2023). While, by 2050, the predicted annual cost of the damage caused by climate change would range from \$2.7 trillion to \$3.1 trillion (Cruz & Rossi-Hansberg, 2023). This includes the price of harm to people's health, property, agriculture, as well as infrastructure. This cost is expected to increase over time as the impacts of changes on climate become more acute, the world's poorest nations are most defenceless to the negative economic effects of changes on climate. Egypt will face more environmental pressure due to climate changes, like as an increase in temperatures, unpredictable rainfall, increasing sea levels and shoreline erosion, land subsidence, coastal floods, changing soil salinity, and drought (Eissa, 2023). Agriculture-related welfare losses are projected to be between 140 and 824 billion Egyptian pounds (EGP) in 2060. Property in the Nile River Delta at threat from Sea Level Raise may be worth between 25 and 56 billion EGP (Elsayed, 2023). Increased temperature and the concentrations of suspended particulate matter may cause an additional 2,000 to 5,000 fatalities annually, decoding into a loss of 70 to 170 billion EGP, which will affect the economy cause more imbalance and reduce economic growth rates. (Cruz & Rossi-Hansberg, 2023).

Economic growth, always measured by (GDP) gross domestic product, (GDP) will provide insight into a nation's economic future. Especially for developing nations with undesirable budget balances. Higher growth projections suggest a greater ability to repay loans and achieve more welfare (Yasser & Eissa, 2023). After calculating inflation, (the GDP) of Egypt elevated to a level of 3.25 % in the year 2021. The economy of Egypt was forecasted to rise by 5.98 % by the year 2028 (Eissa & Khalifa, 2023). Full-year GDP growth of Egypt averaged 4.18 %; its peak in Year 2008 at 7.18 % and fell to a lowest record of 1.94 % in Year 2011 due to political uncertainty (Raihan et al., 2023). An additional measure of the economy that divides an economy of the nation's production per person is (GDP) per capita. Founded on economic growth, GDP per capita can be used by economists to evaluate the level of wealth in a country, Egypt's GDP per capita was an average of 2098.56 USD between 1960 and 2022, with a lowest record of 750.81 USD in Year 1960 and an highest of 4088.90 USD in 2022. (Gamal et al., 2021). Net exports, corporate investment, government expenditure, personal consumption and population make up the five

components of the per capita gross domestic product (El-Rasoul et al., 2020) however these five components can be affected by environmental factors in the time of occurrence, like water availability, winter and summer temperatures, and the area's natural resources—such as rivers and coastlines—among others. Each of these elements affects a nation's ability to grow economically. (Fang, 2023; Li, 2023), Economic growth can be changed due to changes in nature in other words climate changes can affect the process of growth, in any economy's consumption and production (Liu, 2022).

Cereals and grains are very important components of human as well as animal food, (recently used as fuel), the two terms are used frequently interchangeably. Cereals are floras that belong to the grass family, while the eatable seeds of cereals or legumes are grains (Abele et al., 2022). The production of cereals and grains depends on many factors like land spaces, soil, water from rain or other sources, climate conditions, labor, fertilizers, and degree of automation (Asfew & Bedemo, 2022). 37% of cereals produced worldwide are used to produce animal feed, 23% of grains produced in underdeveloped nations are used as animal feed, compared to 56% in developed nations, and the rest of production goes to human food and Fuel (Barakat et al., 2022).

Egypt's agricultural output has increased dramatically during the last thirty years. However, with temperatures anticipated to climb to 3.1 °C, rain predicted to fall at a rate of 15 mm, and evapotranspiration expected to grow by 5 to 21 percent, the agriculture sector is expected to be severely damaged by climate change (Abdelaal & McFadden, 2019). Cereal output tends to rise from 1972 to 2021, reaching 22.3 million metric tons in 2021, despite significant fluctuations in recent years (Alnjar et al., 2020). However environmental changes are expected to result in a 5.9 percent drop in Egypt's agricultural productivity. The projected decrease in agriculture productivity will be, 9.4% in fruits and vegetables, 6.4 percent in rice, 2.3 percent in wheat, and 11.9 percent in grains (Sarhan, 2022).

The researcher found that the neglect of studying the connections between Global Warming, Economic Growth, and Cereal Production in developing countries as well as Egypt, could be an issue or key issue for this research because most of the Literature and models - to the knowledge of the researcher - did not investigate the relationship between the three above mentioned variables, other researchers pay attention to Global Warming and Cereal Production, they neglect the Economic growth variable, which reduces the accuracy of estimation of such relationship and reduces the ability to achieve goals of such investigation, in the presence of correlation

between the three variables as an emerging phenomenon. Is it possible to measure the influence of Global warming on economic growth and Cereal Production, in Egyptian Case?

Also, this study expands upon the work of (Abdelaal & McFadden, 2019; Gamal et al., 2021; Li, 2023; Siam et al., 2022) and adds the following to the body of literature:-

First: - This study will inspect the connection between global Warming, Economic Growth, and cereal Production by putting light on the Egyptian case, in the period from 1960 to 2022, as the three variables of this study are connected and affecting each other.

Second: - The relationship between the three variables of the study will be examine in the both short run and long run for the Egyptian case and also in direction by using (Pairwise Granger Causality Tests)

Third: - The study will produce a policy recommendations for decision makers in Egypt and direction for future research.

The sections of this Study are organized as follows: Section two covers the literature review; Section three covers the materials and methods; Section four covers the results and discussion; and Section five covers the conclusion, policy recommendations, and routes for future studies..

## **Literature review:**

### **Empirical literature.**

A study conducted by, Abele et al. (2022) to evaluate Ethiopia's key cereal produces demand using secondary data taken from the Social Economic Survey of Ethiopia, which contains 1700 of households categorized as cereal producers. In order to predict the demand limitations for the main crops of cereal, this research uses the (AIDS) Almost Ideal Demand System model and descriptive data. Empirical findings show that the percentage of grain spending is influenced by crop prices, other crop prices, and demographic variables. All of the selected cereals have estimated income elasticity values that are positive. As commodity prices rise, household reaction to the demand for cereal crops declines. Every grain crop examined in this article is regarded as a regular good. The study finds that the price elasticity of cereal crops is larger than their expenditure elasticity. This suggests that pricing matters more than income.

Another study by, Asfew and Bedemo (2022) examines how the changing on climate, relates to Ethiopia's grain crops production. In this study an error correction factor co-integration was used using the (ARDL)

model, Autoregressive Distributed Lag. The model assessment justifies the presence of a relationship in long run between cereal crop production, climate change variables (precipitation besides temperature), and other variables. Temperature changes have a large harmful influence on cereal crop productivity, but precipitation has a favorable and considerable long-term impact. Arable land, fertilizer use, and emissions of carbon dioxide all have a positive and large long-term impact on the output of cereal crops. In short-term participation of Labor force also has a significant and positive impact on the production of cereal crop. The findings of the study show a long-term correlation between the yield of cereal crops and factors related to climate change. Research and development in agriculture should concentrate on cultivating cereal crops with high-temperature tolerance.

From another dimension, Abdelaal and McFadden (2019) conducted a study with primary goal to evaluate and forecast the area of cultivation by using time series 1980 - 2017 to anticipate production of grain with respect to a different productivity situations in Egypt. Results point to a negative impact on agricultural productivity, particularly during the summer, from a possible decrease in the flow of the Nile into Egypt. This would result in fewer farmed areas and lower crop yields. The results imply that as Egypt's population rises and its options for reclaiming land remain restricted, the country's dependence on imports will continue and imports of grain will rise.

Similar study was conducted by, Alnjar et al. (2020) to estimate and analyze factors influencing output and productivity of major cereal crops in Egypt and Iraq between 1995 and 2016, which are known for having poor production. Three crops were chosen: rice, barley, and wheat. The assumption of the study was that, between 1995 and 2016, there was a decline in the three crops' yield as a result of several factors obstructing crop development. The two-stage normal least squares approach was applied, and based on the concepts of economic theory, the findings of the quantitative method were interpreted to assess the study's theoretical component. As a result, the amount of rice produced in Iraq and Egypt is negatively impacted by the economic exposure to agricultural conditions.

A study suggests an economic evaluation model for world-wide economy with high geographical determination, conducted by, Cruz and Rossi-Hansberg, (2023) using model include several adaptation strategies to local temperature fluctuations, such as expensive migration and trade, local technical advancements, and local fatality rates. Based on local temperatures, the researchers develop damage functions that quantify the model resolution and assess the effect of fluctuations of temperature on a region's basic production besides facilities. According to the study global warming causes

welfare losses that vary greatly by region, with increases in some northern latitudes and losses of 20% in regions of Africa and Latin America. Spatial inequality rises overall. While there is considerable uncertainty on average utility impacts, it cause relative losses across the world. Other findings demonstrated that innovation and migration are crucial adaptive strategies. The study analyze the effects of renewable energy subsidies, abatement technology, and carbon taxes. Carbon taxes slow down the usage of fossil fuels and contribute to a flattening of the curve of temperature, but they work considerably better when an abatement technology is developed.

In another study by, Diffenbaugh et al. (2021) proves the fact that increased crop insurance losses in the United States are mostly attributable to global warming. According to the researchers' estimates, county-level temperature patterns were responsible for \$US27.0 billion, or 19%, of the insurance of the crop losses at national level between 1991 and 2017. Furthermore, the researchers calculate that in the most expensive single year (2012), observed warming accounted for nearly half of all losses. Besides, a thorough examination of several global climate model simulations has shown extremely strong evidence that crop insurance losses in the United States have escalated due to human-caused climate forcing. Important quantitative data regarding the financial prices of the global warming that has just occurred (accompanied by the costs of particular severe occasions) and the economic advantage of mitigation and/or adaptation alternatives are provided by these sector-specific estimates.

According to a study conducted by, Eissa (2023) with a purpose of examine, over a time series spanning 1971 to 2022, the link between ecological footprint and economic growth in Egypt. The Key findings are GDP and ecological footprint have a strong, positive association both in short and long run. This indicates if Egypt's GDP increases by (0.61percent), the ecological footprint will increase by (1percent) in the short run. Also in the short run, there is strong negative link among natural resource rent and ecological footprint; but, over time, there is a significant positive association. In the short run, there is no substantial positive association between gross capital production and ecological footprint; nevertheless, over time, there is a huge positive relationship between the two. In the medium term, there is a correlation between unemployment and inflation and ecological footprint.

In the path of studying the effect of Economic growth happening on other economic variables, Eissa and Khalifa, (2023) used in their study tax revenue as their own variable, the study uses (ARDL) model, Autoregressive Distributed Lag approach, with six variables to measure the effect of economic growth on tax revenue in the Egyptian economy from 1975 to

2022. This study is important because, unlike previous research, the researchers quantify the impact of economic growth on tax revenue in Egypt rather than the other way around. This way far apart from previous studies. According to the findings, neither gross capital formation nor unemployment were significant. In the short term, GDP currency and GDP per capita were important, but in the long run, consumer price inflation was important. Key words: Autoregressive Distributed Lag (ARDL), tax revenue, economic development, and Egypt.

In study to examine the expansion of Egypt's three major cereal crops; rice, wheat, and maize, as well as the factors that contributed to these crops' output increases between 1975 and 2017 by, El-Rasoul et al. (2020) this study divided to three intervals: 1975-1986, 1987-2000, and 2001-2017, with respect to the whole period 1975-2017, founded on the data concluded of the Chow Breakpoint test. The findings demonstrated that increases in yield, rather than changes in area, were more important for the expansion of wheat, rice, and maize output over the research periods. Thus, the study highlights that the impact of vertical development is higher than the horizontal expansion..

Another study looks on how Egypt's foreign tourist industry has been affected by climate change between 1990 and 2020, conducted by, Elsayed (2023) this study employed the (ARDL) model, autoregressive distributed lag, to simultaneously inspect short run as well as long run estimates changes in temperature, rainfall, & carbon dioxide emissions were used to assess climate change, with arable land (percentage of land area) and gross capital creation (as a percentage of GDP) acting as control variables. Findings show that while temperature besides rainfall rate has a favorable impact on foreign tourism earnings over the short and long term, they are not considerable. Moreover, the long-term effects of carbon dioxide emissions on foreign tourism earnings are adverse.

since protecting agricultural output is of utmost importance, study conducted by, Gamal et al. (2021) to evaluate the effects of the two global warming scenarios (GW) levels (1.5 and 2.0 °C) on Egypt's yields of maize as well wheat by presenting and analysing the fast track predictions made accessible through the Inter-Sectors Impact Model Intercomparison Project (ISI-MIP). Results showed that the effect of change in temperature on crop output varied geographically. On national average change in yield of wheat under GW1.5 and GW2.0 was 5.0% (-3.0% to 14.0%) and 0.0% (0.0% to 9.0%), respectively, as compared to the referred circumstance. Regarding maize yield, under GW1.5 and GW2.0, the national regular changed by around -1.0% (-5.0% to 3.0%) and -4.0% (-8.0% to 2.0%), respectively.

Wheat yield may benefit from GW1.5, but if warming exceeded levels by 2.0 °C, the benefit vanished. However, the models disagree on the direction of change, it is uncertain how maize production in Egypt will differ under the GW1.5 and GW2.0 scenarios. Reducing rise in temperature by 1.5 °C would lessen the yield. since protecting agricultural output is of utmost importance.

A Study examines the effect of global warming severity on financial risk conducted by, Gao et al. (2023) to analyzing financial risk, global warming, and the financial data of 30 Chinese provinces from year 2010 to year 2020. Principal Results discovered that financial risk is impacted by global warming and that it significantly positively influences the level of financial risk. Governments, businesses, financial institutions, and families are all significantly impacted by global warming. The ways that variations in the environment affect financial risk are not uniform. In economically developed regions, there will be an increase in the buildup of financial risk due to global warming. Financial concerns will arise from it as a result of declining resident incomes, declining business profits, an increase in quantity of loans that banks and other institutions view as nonperforming, and a widening of the budgetary deficit. The economy will suffer as a result of each and every one of these consequences.

In a related study by, Raihan et al. (2023) investigated the dynamic relationships between Egypt's CO<sub>2</sub> emissions and economic development, study the use of fossil fuels and renewable sources of energy, tourism, besides agricultural output. The study used time series data for years 1990 – 2019, the researcher examined data using the (DOLS) Model, Dynamic Ordinary Least Squares technique. The outcomes showed that, tourism, economic growth, and the use of fossil fuel energy all increase CO<sub>2</sub> emissions that harm Egypt's environment, higher shares of renewable energy and higher agricultural productivity will reduce CO<sub>2</sub> emissions and improve environmental quality. Other estimators like canonical cointegrating regression (CCR) and fully modified least squares (FMOLS) produced comparable findings. Also, the causal link between the variables was ascertained by the Granger causality paired test.

According to Regmi et al. (2022) study which investigated the impact of total cereal production, total harvested cereal area, and total cereal yield on the economic growth and the performance of environment of Nepal from 1990–2018. Using extensive time-series data, the research looked at possible fractures and determined the cointegration connection between a chosen variables. The outcomes confirmed that cointegration occurs when structural fractures are present. In a similar mood, the ARDL method reveals that urbanization, renewable energy, and forests are important contributors to



environmental quality improvement in Nepal. Empirical results imply that forests and their resources have an impact on economic expansion and offer proof of the curse of the resources. Another findings, urbanization, agricultural development, and renewable energy are some of the elements driving the nation's economic expansion. By accounting for the influence of several measures of agricultural growth, the results further validate the existence of the environmental Kuznets curve.

Goal of study conducted by, Sarhan (2022) was to identify the key factors influencing agricultural investment in Egypt from 2000 to 2020. Using Egypt's factorial analysis for the years 2000–2020. The factorial analysis's findings show a substantial correlation between the first factor's saturation level and other variables influencing investment in agriculture on Egypt. Variable of technological level is the highest position on this factors, with a saturation value of 0.979. It was accompanied with the variables of total Labor in agriculture, total income from agriculture, total exports of agriculture, total crop zone, total worth of investment in agriculture loans, and total value of imports from agriculture, with corresponding saturation values of approximately 0.968, 0.964, 0.958, 0.925, and 0.806.

Another important study to my research aims to examine the probable economic implications of climate change on Egypt's most important cereal crops, conducted by Siam et al., (2022) the study applies the Policy Analysis of Agricultural Commodities and Trade - International Model. The findings indicate that there is a good chance that Egypt's cereal crops—wheat, maize, and rice—will be negatively impacted by climate change. Their productivity is expected to decline by 9.06%, 19.54%, and 8.53%, respectively, and their overall production will be reduced by approximately 11.5%, with the productivity of wheat, maize, and rice falling by 2.3%, 21.8%, and 6.4%, respectively. As a result, prices for some agricultural items rise along with the demand for them. While the price of rice will increase to around 667.34 US dollars per ton, the price of wheat and maize will reach approximately 391.90 and 342.31 US dollars per ton, respectively.

Through investigating production and indicators of consumers through the years from 2003 to 2020, a study made by, Soliman and Soliman (2022) this study seeks to understand Egypt current state of maize production as well as consumption. It also seeks to identify the marketing challenges that farmers face and learn about their opinions about the policy of government in agricultural sector. Findings indicated the following, between 2003 and 2020, Egypt's maize-planting area varied among dual bounds: the lowermost, approximately 1657.8 thousand acres in 2003, and the uppermost, approximately 2335.63 thousand acres in 2018. During that

period, the regular cultivated area was roughly 10.03 thousand acres. Upon examining the production expenses, another discovery showed that they had begun to exhibit a statistically significant and rising tendency at the statistically significant threshold of 0.01; the annual cost rise at that time was equivalent to about 372.17 pounds/acre, or 10.84% of the regular production expenses. The difficulties of not getting the crop's price directly rank uppermost, accounting for about 14.18% of the total, according to an analysis of the comparative rank of the marketing matters faced by maize farmers in Egypt. Marketplace distance from the production places and risk from price variation rank second and third, correspondingly.

To understand the mutual effect between economic growth and other economic factors I review the study conducted by, Yasser and Eissa (2023) this study investigates how economic growth, foreign aid, and Economic Freedom affect SAARC nations' economic growth. Moreover, it will look into the immediate and long-run effects on these nations' GDP per capita. The study relied on information for five of the eight SAARC members. GDP per capita is the independent variable, and the HDI, ODA, FDI, and economic freedom index are the dependent variables. A unit root test used as first step in the approach, after which the FMOLS model will be implemented. The main findings are; the HDI and economic freedom index have a beneficial impact on economic growth, whereas FDI and ODA have a negative impact.

In a study examined the effects of global warming on the economy, with a particular emphasis on four key areas: GDP, inflation, the energy sector, agriculture, output from various industries, and tourism. Conducted by, Zhang (2023) the study found that the cost-effectiveness of implementing policies to mitigate and adapt the financial effects of global warming is a very important issue. According to the study, if nothing is done, global warming might cut GDP by up to 18% by 2050. However, the costs of adaptation and mitigation are probably going to be less than the costs of doing nothing. The study suggests that governments, corporations, and individuals must act quickly and together to address global warming as a systemic risk.

### **Theoretical and Policy literature.**

A policy paper discussing the effect of change in climate on Egypt's agriculture sector was conducted by, Barakat et al. (2022) as the impacts increase in strength and occurrence, according to the authors the effects of change in climate on agriculture has to be screened by decision makers to save

the incomes of over 25 million people in the sector of agro-food and feed over 100 million people, according to this paper such effect has emerged as one of the government's top policy concerns. The main problem in Egypt is adjusting activities to change in climate into agriculture is not a science and is not an arrangement challenge however it is an application. Although there is significant growth in policies related to agriculture, as well as continuing struggles to understand water, food, challenges, and improvement, the definite application of the change in climate reworking policies have not yet spread between Egyptian agriculturalists and practitioners the field. Such policy paper proposes three policy choices: a) dedicated climate-finance resource mobilization unit; b) agricultural technical innovation through technology transfer; and c) economic and market structural policy choices on the agro-food industry.

On the same direction of the previous study, Diffenbaugh and Burke (2019) assume that there is a chance that global warming has created economic inequality more severely globally, with population-weighted between-country disparity having increased by about 25% during the previous 50 years. In contrast to a sphere deprived of anthropogenic heat, hotter nations have gotten stronger as well as major drops in economic yields over the previous 50 years, while cooler nations have gotten upsurges in economic yield. Such upsurge due to warming's effect on yearly economic growth. Thus, the economic inequality related to historical alterations in energy consumption, and productivity, has perhaps been made worse by the global warming transported by mainly the usage of more fossil fuels.

Due to the fact that the issue of global warming has gained more and more attention and the consequences of this issue begin to affect people everywhere, through the creation of various natural catastrophes, the removal of accessible habitat for species, and the creation of an environment that is too harsh for creatures to survive, global warming has an impact on the ecosystem. A study conducted by Fang (2023) proves that humans are impacted by global warming because it decreases food output and resources, which raises competition. The causes of global warming should be the main emphasis of any solution to the issue. The primary driver of global warming is the intense greenhouse effect. In addition, a number of positive feedback loops, the sun's growing mass, and the resulting increase in solar radiation all play a part in the global warming issue. In this study, multiple solutions were developed based on four distinct factors: the policy, geological, biological, and chemical elements.

Rendering to study by, Fatima et al. (2020) temperature, day length, and growing degree days (GDDs) all affect cereal crop growth and

development, making them sensitive to certain settings throughout particular seasons. Because of human activities, the global temperature is rising. Crop growth and development are disrupted by temperature rise. Crop phenological development is mostly altered by disturbance, which also has an impact on economic yield. Findings of this study are; scholars and agriculturalists adjust to such phenological changes by adjusting cultivar shifts as well as sowing times, that is can lengthen or shorten the period of crop growth. However, breeding genotypes appropriate to the environment, boosting genetic diversification, and enhancing grain yield through agronomic management can all help assure food security. A variety of management techniques are proposed to address climate change in light of the previously described findings.

Economic recessions have repeatedly devastated Africa's emerging nations, particularly in the last ten years. Almost 3 billion people living in absolute poverty in Africa. Therefore, finding a solution—and using an economic strategy to find a long-run remedy—is essential. Through study implemented by, Kyarem et al. (2021) use analytical methodology in political economy. Examining emerging nations in North of Africa (with Egypt), East of Africa (with Kenya), Southern Africa (with the Republic of South Africa), and West of Africa (with Nigeria and Ghana), the main findings are; the importance of agriculture is on remedy. The study highlights the advantages of agriculture that may be used to break free from the grasp of the economic downturn, using Nigeria as a model. The primary conclusions suggest that the technological aspects of agricultural production, particularly grain production, should be reengineered in the near future. Agricultural Cooperative Societies are formed in both country side and city regions as prerecession structure for all countries, under the guidance of traditional authorities.

The detrimental effects of human activity-caused global warming will be the main topic of a study conducted by, Li (2023) the study discuss the topic of global warming, increase in temperature of Earth's surface as well as atmosphere due to different activities of the human. The increase of heat-trapping gases similar to carbon dioxide and methane in the atmosphere is what causes global warming, and it is known as the greenhouse effect. The influences of global warming on ocean thermal increase, the melting of glaciers and polar ice caps, and changes in ocean forms have all been related to an upsurge in sea levels around the world. The economy will be impacted by all of these developments, this study examine the effects of each component. Upcoming generations shouldn't be involuntary to pay the bill for pollution and additional costs resulting from human activity causing

global warming. More using of fossil fuels reduce the stock of energy and resulting in less economic activity, more prices and more scarcity.

Five categories, agricultural illnesses and vermin, agricultural management, agricultural ecosystem, and possible agricultural production, are used in study conducted by, Liu (2022) to outline the influence of change in climate on agricultural output of China. Based on the study, the pressing issues facing agricultural output of China, are highlighted, and countermeasures to mitigate effects of change in climate stay proposed within the light of perspectives of policy, technology, scientific investigation, as well as collaboration. These will serve as an escort for other administrations in addressing the opposing effects of global warming and proceeding the sustainable growth of the sector of agriculture. Agricultural output in China has been significantly wedged by global warming, mainly in relationships of the improved unsatisfactory distribution of heat and water resources and occurrence of extreme climate events. These influences have elevated the risk allied with production in agricultural sector.

In another study conducted by, Uteulin and Zhientaev (2022) with the objective to create and put into practice a systematic strategy for raising the efficiency of grain production. The study's approach is based on time series analysis, which allowed for the identification of key patterns in the production of cereals in the area and the creation of predictions. The Kostanay region was identified as one of the primary cereal-producing regions in the nation upon the implementation of the recommended method in that area. The area had severe weather in 2019, which led to a significant drop in crop production. Nonetheless, the analysis predicts that there will be a considerable rise in wheat output in the future and that cereal production will grow significantly in the region.

In summary, the literature reviewed makes it clear that no research has examined the connection among Global Warming, Economic Growth, and Cereal Production in Egypt, understanding such relationship when discussing the issues related to Economy or environment is crucial for improving understanding of the factors affecting ways in which cereal production variety and complexity impacted by environment and, eventually, the economy. As a result, this study closes the apparent gap that the other studies did not address.

**Summary for the Main Literature - Table (1)**

#	Author	Main variables	Countries	Model used
1	Abele et al. (2022)	cereal producers, cereal prices, income & Quantity produces	Ethiopia	(AIDS) model
2	Asfew and Bedemo (2022)	cereal crop production, climate change, Arable land, fertilizer, carbon dioxide emissions. labor participation	Ethiopia	(ARDL) model
3	Abdelaal and McFadden (2019)	Area Harvested, Total Production, Yield Prices, Clover Area, Water	Egypt	(OLS) Model
4	Alnjar et al. (2020)	Temperature, Quantity produced, Water, Land area Inflation	Egypt and Iraq	Two-stage normal least squares
5	Diffenbaugh et al. (2021)	per capita GDP, temperature, precipitation country fixed effects	USA	Primary regression
6	Cruz and Rossi-Hansberg, (2023)	temperature changes, costly trade, migration, technological innovations, Fatality rates	Parts of Africa, Latin America	statistical down-scaling
7	El-Rasoul et al. (2020)	major cereal crops—rice, wheat, and maize—the factors that contributed to these crops' output	Egypt	Chow Breakpoint test.
8	Gamal et al., (2021)	Two global warming (GW) levels (1.5 and 2.0 °C) on wheat and maize yields	Egypt	(ISI-MIP).
9	Gao et al., (2023)	Financial risk, global warming Governments, financial institutions, families	China	ARDL model

<b>10</b>	Raihan et al., (2023)	CO2 emissions, economic development, fossil fuels, renewable energy, Tourism, Agricultural output.	Egypt	(DOLS) technique.
<b>11</b>	Regmi et al. (2022)	cereal output, cereal harvested area, cereal yield, forest, renewable energy,	Nepal	ARDL Model + OLS
<b>12</b>	Siam et al. (2022)	cereal crops—wheat, maize, and rice, surface Temperature	Egypt	International Model for Policy Analysis

**Importance of the study:**

- Absence of clarity in the link between Global Warming, Economic growth, and Cereal production when predicting any economic and environmental issue.
- The importance of the current study about global warming, economic growth, and cereal production in Egypt as emerging topic for more studies in the future.
- Important to study different effects on humans and animals food production in the time of economic slowdown.
- Scarcity of empirical studies on the connection between global warming effects, Economic growth, and Cereal production in developing countries like Egypt.
- A need to work on the Macroeconomics level to measure and understand the mutual impact of Global Warming effects, Economic growth, and Cereal production to help policymakers.

**Objectives of the study:**

- Understand the meaning of the three variables, as shown in Literature & study relationship between them.
- Study such relationship between global warming, economic growth, and cereal production in Egypt in both the short run and long run.
- Find most appropriate model or methods and levels of integration between Global Warming, Economic growth, and Cereal production in Egypt Economy.
- High light reliable instruments to assess and mitigate the negative effects to help decision-makers.

## Methodology:

### Hypotheses:

- (H1) - There is a correlation between Global Warming, and Economic growth, in the Egyptian Economy.
- (H2) - There is a correlation between Global Warming, and Cereal production in the Egyptian Economy.
- (H3) - There is a correlation between Economic growth, and Cereal production in the Egyptian Economy.

### Variables and data

This study depends on time series analysis depending on secondary data obtained by the World Bank.

**Table (2):**

#	Variable	Symbol	Unit of measurement	Source	Used in Literature
1	Global Warming	TEMP	Temperatures Annual Average Mean	World Bank	Positive
2	Economic Growth	GDP/C	GDP per capita growth (annual %)	World Bank	Positive
3	Cereal Production	CEREL	Cereal production (metric tons)	World Bank	Positive

### Proposed model

The function that expresses the variables will be as follows:

$$Y_{1t} = \mathbf{f}(X_{1t}, X_{2t}, X_{3t}, T_t)$$

Where

$$\mathbf{TEMP} = \mathbf{f}(\mathbf{GDP/C}, \mathbf{CEREL})$$

This study will examine these variables depending on the ARDL test and its validity in the long run which will be explained by the following model:-

$$\mathbf{TEMP} = \beta_0 + \beta_1 \mathbf{GDP/C} + \beta_2 \mathbf{CEREL}$$



**Results:**

To estimate the results, the researcher depends on several statistical tools. This analysis begins with the statistical description and then moves to the unite root test ending with the ARDL test:-

**Table (3): Descriptive statistics:-**

	TEMP	GDP/C	CEREL
<b>Mean</b>	22.73516	2.802844	16.47107
<b>Median</b>	22.71500	2.389888	16.35874
<b>Maximum</b>	24.57000	10.78415	16.99869
<b>Minimum</b>	21.58000	-3.966167	15.42674
<b>Std. Dev.</b>	0.637962	2.574625	0.504281
<b>Probability</b>	0.519399	0.055512	0.031132
<b>Sum</b>	1409.580	173.7763	1014.242
<b>Observations</b>	62	62	62

*Source: Researcher calculations*

In describing the data statistically, the mean of TEMP was (22.73516) along the years while the median of TEMP was high (22.71500). The lowed recorded TEMP was (21.58000) at year 1961 while the highest was (24.57000) at year 2018. It found that the greater Std. Dev. is the GDP/C followed by TEMP then CEREL in table 3. Also, it is clear that in all results the mean is greater than the median which means that the tail of the curve will be at the highest values of all variables used.

**Table (4): Pearson Correlation Coefficients of the variables in phenomenon**

	TEMP	GDP/C	CEREL
<b>TEMP</b>	1.00		
<b>GDP/C</b>	-0.843101	1.00	
<b>CEREL</b>	-0.833600	0.663469	1.00

TEMP was significantly correlated with GDP/C, and CEREL. However, it was the same degree of strongly correlated with GDP/C, and CEREL. However GDP/C Has a moderate correlation with CEREL. Correlations are a good indicator for the relationship between variables but do not consider the simultaneous effect of different variables on the TEMP.

**Unit root test:**

This test began with the following hypotheses:

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H0: variables have unit root and stationarity.

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H1: variable have neither unit root nor stationarity.

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**Table (5): Unit root test At Level**

		TEMP	GDP/C	CEREL
<b>With Constant</b>	t-Statistic	-1.471	-7.0906	- 6.433061
	prob.	0.0027***	0.050**	0.003***
<b>With Constant and Trend</b>	t-Statistic	-1.3441	-7.0344	- 6.144874
	prob.	0.0043***	0.041***	0.012***

*Notes: (\*\*) significant at the 5%; (\*\*\*) significant at the 1%; and (no) not significant, lag length based on SIC, probability based on MacKinnon (1996) one-sided p-values*

**Table (6): Unit root test At First Difference:-**

		TEMP	GDP/C	CEREL
<b>With Constant</b>	t-Statistic	-3.9438	-2.2933	- 6.433061
	prob.	0.0057***	0.181	0.003***
<b>With Constant and Trend</b>	t-Statistic	-4.1889	-2.2241	- 6.144874
	prob.	0.0044***	0.4582	0.012***

*Notes: (\*\*) significant at the 5%; (\*\*\*) significant at the 1%; and (no) not significant, lag length based on SIC, probability based on MacKinnon (1996) one-sided p-values.*

The calculations regarding the Augmented Dickey–Fuller to verify the presence of the unit root in the series of TEMP are constructed. The calculation is initiated by assuming that TEMP have a unit root test. The calculations were performed with a lag length of zero and a max lag of six. The probability value was less than 0.05, and the critical test values of the independent variable were tested at three levels of significance: 1%, 5%, and 10%. Based on the values given, the p-value shown for the TEMP is almost zero, less than 0.05. The TEMP's null hypothesis is rejected when the probability value is this high, indicating that the series is level-stationary. Consequently, the research's independent variable might be interpreted as steady at both the level and the dependent variable is stationary at the first difference at first difference. As a result, the best model to gauge how an independent variable affects a dependent variable is the ARDL model.

**Table (7): Pairwise Granger Causality Tests**

Due to a lack of the literature on causality between GDP and both Cereal Production and Global warming in the Egyptian economy, the Granger causality test, was used to differentiate which variable was a dependent and which variable was an independent. (Lags: 2)

Null Hypothesis:	Obs	F-Statistic Prob.	
CEREL does not Granger Cause GDP	62	0.36438	0.6963
GDP/C does not Granger Cause CEREL		1.24218	0.2967
TEMP does not Granger Cause GDP	62	0.91463	0.4067
GDP/C does not Granger Cause TENP		2.96927	0.0596
TEMP does not Granger Cause CEREL	62	0.68852	0.5066
CEREL does not Granger Cause TENP		12.0036	5.E-05

In the initial experiment, CEREL has an impact on GDP/C. The next research will thus evaluate the short- and long-term impacts of CEREL on GDP/C. Whereas TEMP has an impact on GDP/C and CEREL in the second and third trials. Thus, the next analysis will evaluate TEMP's short- and long-term effects on Egypt's GDP/C and CEREL.

**Table (8): Co-integration test using ARDL after 5 lags**

Variables	F test statistic	Decision
TEMP	10.654	Co-integrated
GDP/C	8.375	Co-integrated
CEREL	9.310	Co-integrated

*Sources: researcher calculations based on 62 observations / need to reject the null hypothesis*

**Table (9): ARDL Model for Short run**

Variable	Coefficient	Std.Error	t-Statistic	Prob
TEMP	0.653355	0.151156	4.32238	0.0002
GDP	0.415771	0.124280	3.345436	0.0015
CEREL	-0.634422	0.917297	-0.691621	0.4920
C (Constant)	1.026983	0.484875	2.118035	0.0443
R-squared	0.827384	Mean dependent var	2.908505	
Adjusted R-squared	0.804141	S.D. dependent var	1.295602	
S.E. of regression	0.982780	Akaike info criterion	2.840254	
Sum squared resid	32.44029	Schwarz criterion	2.978672	
Log likelihood	-39.5277	Hannan-Quinn criter.	2.902501	
F-statistic	19.87253	Durbin-Watson stat	2.599669	
Prob(F-statistic)	0.000483			

Using Egypt's GDP/C and CEREL as dependent variables and TEMP as an independent variable, the autoregressive distributed lag model is applied to reveal particular data presented in the preceding table. Sixty observations in all are included in the test and are considered after modifications. The model selection criteria are based on the Akaike information criterion (AIC), and

four lags are chosen automatically. With t-values more than two and p-values less than 0.05, the t statistics and probability values demonstrate that the model is fit.

**Table (10) Conditional Error Correction Regression.**

Variable	Coefficient	Std.Error	t-Statistic	Prob
<b>C (Constant)</b>	1.026983	0.484875	2.118035	0.0443
<b>GDP/C</b>	0.346645	0.151156	-2.293286	0.0305
<b>CEREAL</b>	0.034422	0.117297	0.131621	0.0125

Include the ARDL long-run form's conditional error correction regression. The dependent variable in this regression test is CEREL, whereas the independent variables are TEMP and GDP/C. Time-series data with 62 observations for each of the dependent and independent variables are used in the ARDL model, which is run as a case with constrained constant and no trend. Since the constant and TEMP p-values are both less than 0.05, the model's results are considered significant.

**Table (11) Restricted Constant and No Trend**

Variable	Coefficient	Std.Error	t-Statistic	Prob
<b>C (Constant)</b>	2.962638	0.545454	5.513500	0.0003

Additionally, since the probability is smaller than 0.05, the constrained constant in the level equation and the absence of a trend value above demonstrate that the link is significant. The association is also favorable, as indicated by the coefficient value of 2.962638. Accordingly, the values in the preceding Table demonstrate a long-term, direct, and substantial link between the dependent and the two independent variables.

**Table (12). ARDL Error Correction Regression.**

Variable	Coefficient	Std.Error	t-Statistic	Prob
<b>TEMP</b>	1.432795	0.521007	2.750048	0.0014
<b>GDP</b>	2.315771	0.223240	2.045436	0.0015
<b>CEREAL</b>	1.745232	0.917297	-0.691621	0.0230
<b>CointEq(-1) *</b>	-0.34665	0.148217	-2.33876	0.0276
R-squared	0.183704	Mean dependent var	0.004049	
Adjusted R-squared	0.183704	S.D. dependent var	1.098433	
S.E. of regression	0.982780	Akaike info criterion	2.621391	
Sum squared resid	32.44029	Schwarz criterion	2.699452	
Log likelihood	-39.5277	Hannan-Quinn criter.	2.701240	
Durbin-Watson stat	2.599669			
Prob(F-statistic)	0.000483			

\*The coefficient of the cointegration equation

The ARDL test on the error correction model is presented in Table (12). Whether a long-term link exists between the variables is determined by the statistical estimation displayed in the table. The likelihood of anticipating a lengthy association is estimated using the cointegration equation's coefficient, which has a value of -0.34665. This score indicates that the long-term adjustment is negative and significant when paired with the probability value of 0.0276).

**Results Summary:-**

	<b>Short run</b>	<b>Long run</b>
<b>TEMP</b>	Significant +	Significant +
<b>GDP/C</b>	Significant +	Significant +
<b>CEREL</b>	In Significant -	Significant +

The following points are extracted from the results of this research:-

- According to ARDL model Short and Long run the researcher found that there is a correlation between Global Warming (TEMP), and Economic growth (GDP/C), in the Egyptian Economy in the period from 1960 - 2022. Which prove the first hypnosés of the study (H1).
- According to ARDEL model Short and Long run the researcher found that there is a correlation between Global Warming (TEMP), and Cereal production (CEREL) in the Egyptian Economy, in the Egyptian Economy in the period from 1960 - 2022. Which proves the first hypnosés of the study (H2).
- According to ARDL model Short and Long run the researcher found that there is a correlation between Economic growth (GDP/C), and Cereal production (CEREL) in the Egyptian Economy, in the Egyptian Economy in the period from 1960 - 2022. Which prove the first hypnosés of the study (H3).
- Such Relationship is vary between short and long run as shown the summary above.

**Conclusions and discussions:**

The three variables of this study are Global Warming represented by (Temperatures' Annual Average Mean), Economic Growth represented by (GDP per capita growth /annual %), and Cereal Production represented by (Cereal production /metric tons) in Egypt from 1960 till 2022 are used and

defined in many Literature like, (Diffenbaugh & Burke, 2019; Diffenbaugh et al., 2021; Gamal et al., 2021; Gao et al., 2023; Kyarem et al., 2021; Eissa & Khalifa, 2023; Regmi et al., 2022; Sarhan, 2022; Uteulin & Zhientaev, 2022; Yasser & Eissa, 2023). However, none of the authors above used the three Variables to gather in one study, which gives my study a privilege over the other Literature on the other hand the three variables of this study are connected and affect each other, another aspect for the importance of my study is absence of clarity in the link between Global Warming, Economic growth (Zhang, 2023) from one side and Cereal production when predicting some economic and environmental issue in a developing country like Egypt as emerging topic for more future decisions and studies. Global warming has many negative sides on both economy and Environment (Barakat et al., 2022), specifically for agriculture and food production such studies will help policymakers and more scholarly work for the future benefit of society, also my study did not focus only on the connection between the three variables of the study, but also shared in the long run and short run effects between the three variables which will enhance more the process of understanding and developing new solutions for any related problems (Asfew & Bedemo, 2022). From my point of view the reason for the results of this study can be interpreted as follow:-

Economic growth may be defined as the process of growing a country's productive capacity in the form of national revenue, it is considered to be essential for any country like to achieve more welfare for its people. (Eissa, 2023) There is a connection between heat waves and Economic growth as production will be decreased, taking for example the tourism stops to country if the heat exceeds certain limits (Elsayed, 2023).

The effect of global warming on GDP per capita is obvious as the heat waves or dramatic temperature changes can spoil the agriculture crops including cereal produced, and reduce the productivity of workers as a result the supply of agriculture will be diminished, and the prices will increase will lead the country to inflation (Gamal et al., 2021).

The heat waves or dramatic temperature changes can upsurge the rates of water evaporation or will lead to water shortage as more demand in irrigation water will be created more demand on water (Regmi et al., 2022). This will increase the cost of production for agricultural products as well as reduce the productivity of crops, which will increase the prices and cause inflation, and in the long run will lead to rescission (Sarhan, 2022).

**Recommendation:**

- The agricultural sector and food production should be supported concurrently by technological adaptation.
- climate-smart crop varieties—those resistant to heat and drought—should be made available, agricultural practices should be improved, farmers should be educated and guided in switching from crops that are severely impacted by climate change to crops that are resistant to pressures from the environment, and the agricultural sector needs to invest more to increase productivity.
- Policies that regulate prices rather than those that target income would be more successful. Moreover, the positive spending elasticity implies that the demand for cereal products will increase in tandem with income. The demand for grains would rise as a result of policies designed to raise income.

**Limitations of the study:**

The application is in Egypt using data from the years 1960 to 2022. We chose the long time 62 years to ensure the accuracy of analysis in the short run and the long run.

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