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Article

Do Climate Change and Institutional Quality Impact on Agricultural Productivity in Nigeria?

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Abstract: This study analysed the impact of climate change and institutional quality on agricultural productivity in Nigeria. The study used agricultural output as a proxy for agricultural productivity. In order to examine the hypotheses under the study, the Johansen co-integration test was used to test the time-series properties of the variables. Adopting the Ordinary Least Squares (OLS) estimation technique, the results from the study revealed that some climate change and institutional quality variables have significant impacts on agricultural productivity in Nigeria. In line with these findings, the study recommended among many others that policy makers and the Nigerian government should strengthen efforts towards strengthening institutional variables, integrating climate smart agriculture and investing in agricultural technology (agro-tech) to enhance and improve agricultural productivity in the economy.

Keywords: climate change; agricultural productivity; institutions, JEL Codes: C23, N57, Q25, Q01

1. Introduction

Different phenomena have challenged global and regional economies over time. The Great Depression, trade and military wars, hunger and starvation, plagues, diseases, and a variety of other natural or manmade activities, for example, are all topics of debate in the world's economic history. Today, the world is faced with another problem known as climate change, which is affecting many economies. Climate change is defined as a shift in the climatic condition or system as a result of the long-term accumulation of emitted greenhouse gases (GHGs) in the atmosphere (Ogbuabor et al., 2020).

Although climate change can be influenced by natural (geographic) factors in the atmosphere, research indicates that it is primarily caused by human (anthropogenic) activity such as GHG emissions or flare-ups (Ngongeh et al., 2014). With both causes, the United Nations Framework Convention on Climate Change (UNFCCC) attempted to distinguish between climatic alterations by human-natural sequestration in Belloumi (2014), in that what it considers climate change is the change primarily attributed directly or indirectly to human activities, whereas climatic variability is the change primarily attributable to natural causes. Regardless of this duality, anthropogenic GHG emissions have been established as the primary cause of climate change (IPCC, 1998). Carbon dioxide (CO_2), nitrogen dioxide (NO_2), methane (CH_4), ammonia gas (NH_3), and sulfur dioxide (SO_2) are some of the most common gases.

GH-gases are produced by agricultural activities such as bush burning, deforestation, and even soil cultivation. According to US-EPA (2006) in Ekpenyong and Ogbuabu (2015) agriculture accounts for roughly 14% of total anthropogenic GHG emissions.

On the other hand, climate change affects agrarian economy in multiple ways because agriculture is an economic activity that is subject to natural phenomena. Agriculture is a priority sector, which is why it is a key component of attaining a significant macroeconomic goal of raising national income. The agricultural industry meets the labor force's stomach economics as well as other industry demands for raw materials. Climate change, on the other hand, can stifle agricultural productivity in extreme circumstances (Ayinde, Muchie, & Olatunji, 2011).

The agricultural sector, according to Nastis, Michahidis, and Fotios (2012), is the most sensitive to climate change since climatic features directly affect agricultural productivity. In a different perspective, it has been noted (in Ebele & Emodi, 2016; Ogbuabor & Egwuchukwu, 2017; & Solomon & Edet, 2018) that crop yield and agricultural productivity might have a negative impact on Gross Domestic Product (GDP). Climate change effects on agriculture may be negative or positive depending on the country's climatic condition or geographic location, according to research. Climate change has a strong positive influence on agriculture for countries at mid-high latitudes, but a detrimental effect for low-latitude countries, according to Mendelsohn (1998). According to the IPCC (2007), African agriculture would be extremely vulnerable to climate change, owing to the region's tropical climate (low latitude) and rain-fed agriculture, as well as inadequate climate change adaptive capacities. More recently, research finds that the impacts of climate change vary not just across countries and latitudes but across individual crops (Onyeneke et al., 2022).

In the mid-20th century, 1960 to 1964 precisely, agriculture was the mainstay of Nigeria’s economy accounting for about 62.5% of total GDP (CBN’s report in Ugwu & Kanu, 2012). However, according to Sekumade (2009), following the oil boom era of 1964 to 1974, the agricultural sector was fraught with fiscal negligence and abandonment. From a macroeconomic perspective, agriculture in Nigeria is subdivided into crop production, livestock farming, fishery and forestry with crop production accounting for over 84% of total agricultural output (NBS, 2019). In terms of contribution to GDP, real agricultural output in the period of 2013–2015 accounted for about 23.11% of GDP and about 24.88% by 2016–2018 (NBS, & CBN bulletin, 2019). Interestingly. Government annual fiscal recurrent expenditure on agriculture in 2017–2018 was respectively 50.26 and 53.99 billion naira. These were very paltry sums when compared with Nigeria’s corresponding annual total fiscal recurrent budgetary expenditure. The insufficient fiscal recurrent agricultural allocation is incapable of fast-tracking agricultural output boom and more even, there is a tendency of little or no budgetary appropriation for climate change adaptive strategies. Figure 1 shows the trend chart of Real Gross Domestic Product (RGDP) growth rate and Agricultural Output growth rate and Figure 2 shows the trend chart of Agricultural Output and Government Recurrent Expenditure on Agriculture in Nigeria.

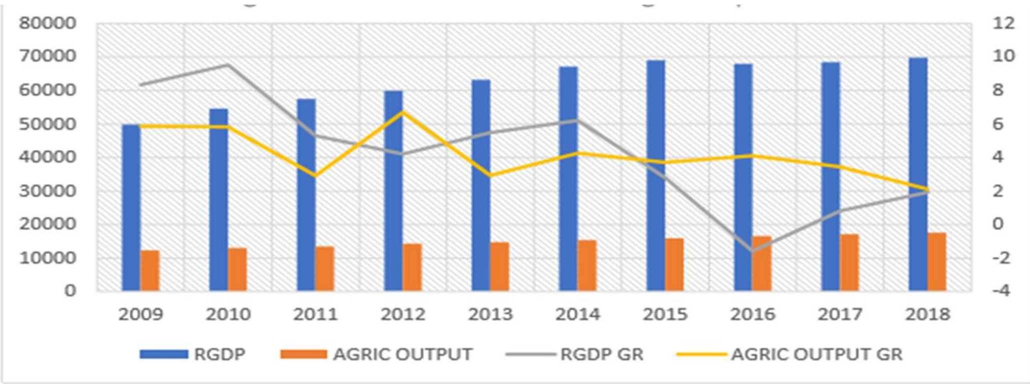

Figure 1. Trend chart of RGDP and Agric Output (Source: Authors' construct; Data: CBN Database. GR: Growth Rate).

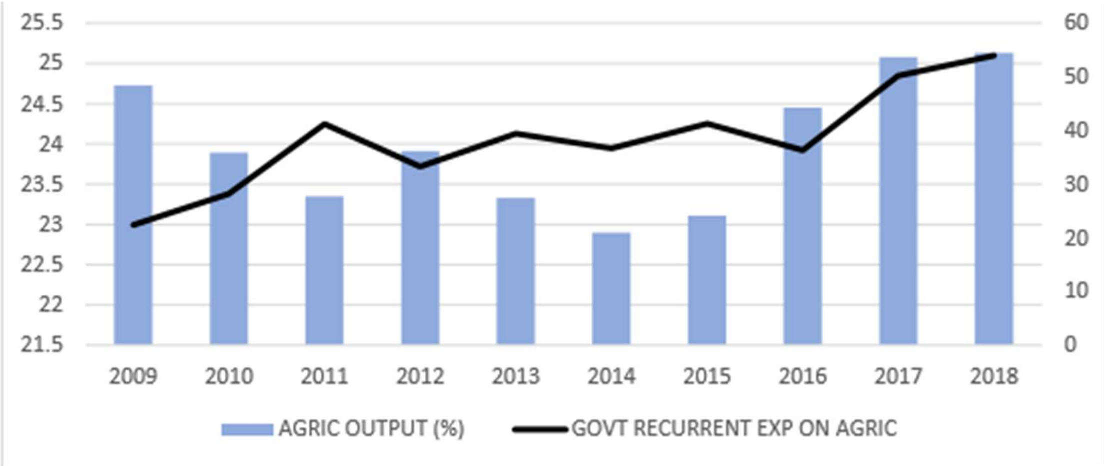

Figure 2. Trend Chart of Agric Output and Govt. Recurrent Expenditure on Agriculture (Source: Authors' construct; Data: CBN Database).

Within the last ten years, average agricultural output as a percentage of RGDP in Nigeria is 23.98% and the growth rate of agriculture has been on the decrease recently. The decrease in productivity of agriculture is also telling on the overall economy. From Figures1 and 2, RGDP and its growth rates in the last ten years have been inconsistent. RGDP grew and fell with a record net fall of 4.37% from 2015 to 2016, followed by 2010 to 2011 at a 4.22% net drop. This inconsistency of aggregate economic growth at a time when the growth rate of agricultural sector output is falling shows how relevant the agricultural sector is to the aggregate economy. No wonder it was rightly pointed out that agriculture is a significant sector as well as the economic mainstay of major households in Nigeria. It employs about 65% of the labour force and remains the highest contributor to non-oil foreign exchange earnings (FAO, 2020).

According to the CBN statistical bulletin (2023), the federal government recurrent expenditure on agriculture was 87.69 billion naira, with more than 1 trillion naira covering administrative expenses alone - suggesting institutional quality issues. Although this represents an increase from the 53.99 billion naira reported for 2018, it still represents an abysmally low (0.614%) of the total 14,287.56 billion naira spent on agriculture. This reinforces the fact that government contribution to the agricultural sector has been low. However, this opens up the argument of institutional quality, that is, even the little available does it translate to agricultural productivity?

Another important variable for discussion in this paper is the relationship between institutional quality and agricultural productivity. A commonly accepted definition of institutions is that they are the formal and informal rules that organise social, political and economic relations (Ogbuabor et al., 2025; Ogbuabor et al., 2024a; Ogbuabor et al., 2024b; Ogbuabor et al., 2023; Ekeocha, et al., 2023 and North, 1990). Furthemore according to Gilad (2025), institutions are “a set of formal rules (including constitutions), informal norms, or shared understandings that constrain and prescribe political actors’ interactions with one another”. Observing that all actions carried out by humans are in one way or another political, depicts similarities in the two definitions, reinforcing the view that institutions are the rules a society imposes on itself. Key features of institutions include the following: they are reproduced through routine actions—they live through enactment; they provide relative certainty and predictability for everyday social, economic and political interactions; they tend to persist over time but can change incrementally and in rare instances, suddenly; they are often internalised and unconscious, in that social actors may not even recognize that they are following institutionalized ways of interacting, they shape behaviour and thus affect developmental outcomes.

Institutions, according to North (1990), are social rules of the game, and their fundamental job in a community is to eliminate uncertainty by providing a structure for everyday life activities such as greeting acquaintances on the street, borrowing money, starting a business, and so on. People cannot respond to one another or follow established agreements without institutions, rules, or interaction guidelines.

Agriculture in Nigeria has enormous potential, but its contribution to economic growth in terms of guaranteeing food security and self-sufficiency is still little. Although several factors could be attributed to this trend, inadequate private investments in agriculture, unequal access to resources, and outdated technology stand out as major contributors. Several policies, programs, and reforms have been put in place to address the sector's inconsistent contribution to output.

The quality of institutions in a country can have a significant impact on agricultural productivity. The quality of institutions, such as the legal and regulatory framework, property rights, and the availability of credit and other resources, can affect the ability of farmers to access the resources and support they need to be productive. For example, a well-functioning legal system that protects property rights and enforces contracts can help farmers secure the financing and other resources they need to invest in their operations. Similarly, a strong regulatory framework that promotes competition and protects consumers can help create a favorable environment for the agricultural sector to thrive. In general, better institutional quality can lead to higher levels of productivity and growth in the agricultural sector.

To buttress the point, Gelgo et al. (2023) find that, in East Africa, stronger institutions lead to improved agricultural value added.

Agriculture is basically a human-centered activity capable of meeting basic human requirements in any society, including Nigeria. From a macroeconomic perspective, Ogen (2007) in Ayinde et al. (2011) asserts that the agricultural sector is multifunctional, resulting in a multiplier impact that benefits other sectors of the economy. When there is a consistent and profitable agricultural production yield, this stance becomes a reality. Apart from specific agricultural inputs (such as agricultural land, permanent and recurrent capital, labor and farm upgrades, and so on), agricultural productivity is mostly influenced by a geographic region's temperature and meteorological conditions, as well as the quality of a country's institutions.

Nigeria's weather condition and tropical climate is richly designed to boost agricultural output yield. This boost in productivity as held by Darku et. al (2016) is a key driver to food security, low level food prices and poverty alleviation in Nigeria and other developing countries.

In the last ten years, agricultural output inconsistency has increased in lockstep with simultaneous gas emissions and flaring operations across Nigeria. According to the World Bank (2014), around 75 percent of Nigeria's gas is flared, and the country's gas flaring activities account for about one-sixth of global gas flaring. According to the statistics of the Nigerian Federal Ministry of Environment, Nigeria's oil and gas sector produces roughly 90 million tonnes of CO_2 (FME, 2015). Ekpenyong and Ogbuagu (2015) also point out that Nigeria's oil and gas sector has around 123 gas flaring sites in the Niger-Delta region alone.

Recurring events in the energy and transportation sectors, in addition to the oil and gas sector, contribute to gas flaring and CO_2 emissions. Due to Nigeria's culture of inconsistent hydro-electric power supply, there is a high demand for generators and diesel engines, as well as the display of road-unworthy autos. These are examples of events that intuitively suggest a contribution to the threat of climate change causatives. Figure 3 clearly indicates that important greenhouse gases, including CO_2, CH_4, and NO_2 have continued to rise, resulting in higher levels of emissions in the atmosphere.

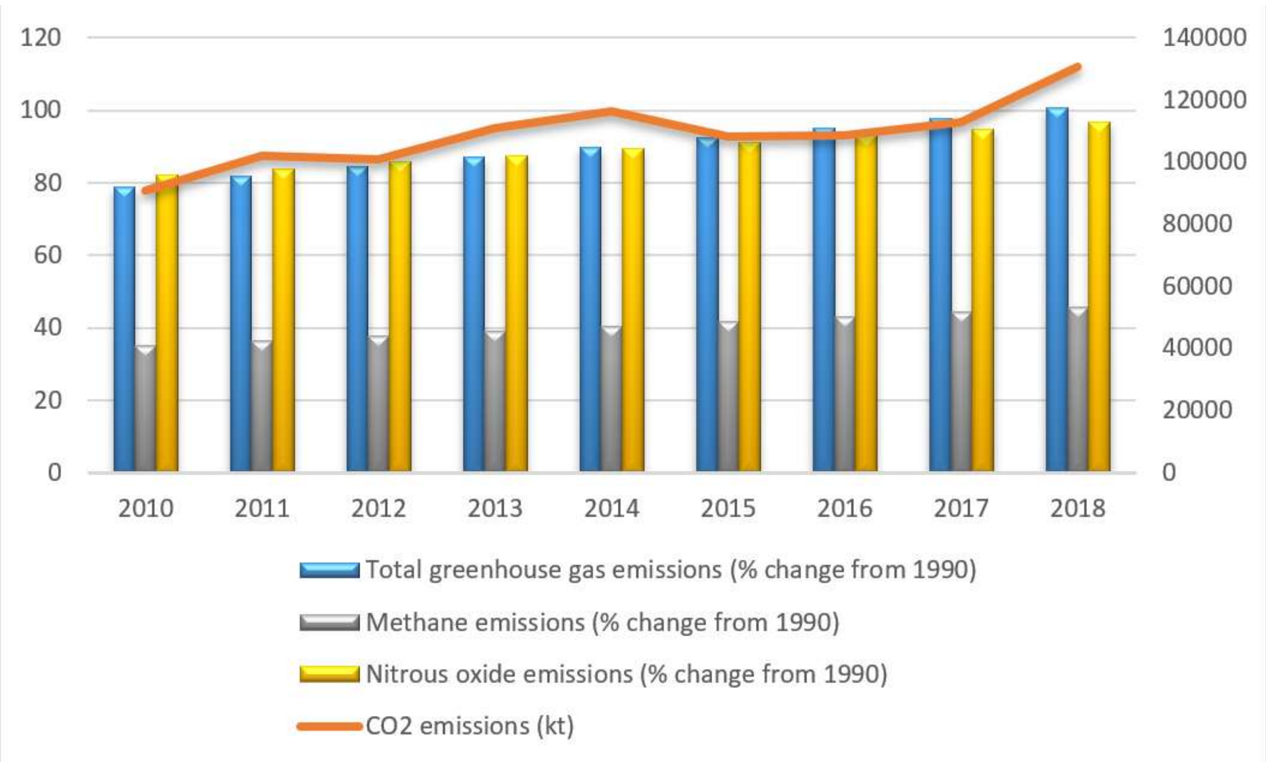

Figure 3. Greenhouse gas trend in Nigeria (Source: Authors' construct; Data: CBN Database).

Today, increases in temperature, rise and decrease in sea level, flooding, variations of rainfall, drought, frequent extreme weather events or temperatures, iced precipitation in Northern Nigeria, land degradation, desertification, loss of bio-diversity, affected fresh water, etc. are all evidences of climate change in Nigeria (Elisha et al., 2017; Ebele & Emodi, 2016; Olaniyi et al., 2013). Additionally, more recent studies have found climate change to be the root cause of much of the violence, insurgencies, forced migration and the attendant food insecurity experienced by northern Nigeria (Sambo & Sule, 2024).

Nigeria's agriculture industry, which is endowed with enormous resources, has the potential to expand. Despite agriculture's enormous potential in Nigeria, the sector's contribution to economic growth through food security and self-sufficiency is still minimal. Although there are various explanations for this trend, low private investment in agriculture, climate change, unequal access to assets and resources, and bad technology are among the most important.

Several strategies, programs, and reforms have been implemented to overcome the sector's inconsistency in its contribution to output. However, an analysis of the outcome based on available data shows that the sector's goals have not been met. Furthermore, a trend analysis of output growth rate and the projection for output share in GDP demonstrate that this sector's performance has been poor.

Overzealousness in policy formulation in contrast to financial commitment; budgetary allocation lower than released funds; unstable government leading to changing policies; lack of effective regulatory and monitoring system; lack of transparency on the part of government; bureaucratic practices; and corruption have all been cited as reasons for this disaster. All of these serve to bolster weak and ineffective institutions. It is undeniable that policies rise or fall in direct proportion to the institutional backing they receive. Separating policy from institutions is difficult in practice since the two concepts overlap in reality (Ajayi, 2003). Against this background, the broad objective of this study is to analyze the impact of climate change and institutional quality on agricultural productivity in Nigeria from 1996–2020.

2. Literature Review

Empirical Literature

Different studies have been conducted to examine the nexus between climate change and some macro and micro variables with outcomes. For example, Gornall et al. (2010) in their paper, reviewed a wide range of processes through which climate change may affect global agricultural productivity and present projections of changes in relevant meteorological, hydrological, and plant physiological quantities from a climate model ensemble to illustrate key areas of uncertainty. There is a lack of understanding on how to appropriately quantify the effects of climate change on drought from an agricultural standpoint, with different criteria yielding highly varied estimates of future risk. The issue is exacerbated by the reliance of some regional agriculture on remote rainfall, snowmelt, and glaciers. Indirect effects like rising sea levels, storms, and disease outbreaks have not been quantified. The extent to which the direct impacts of CO_2 rise on plant physiology will interact with climate change to alter agricultural output is highly unknown. Climate change's overall effects on global agricultural productivity cannot be accurately quantified at this time. In another study, Belloumi (2014) evaluated the impact of climate change on agricultural productivity in Eastern and Southern African countries using a panel data set of eleven countries from 1961 to 2011. The fixed effect country level panel analysis was used to establish that there is a positive relationship between variation in precipitation and agricultural production in Eastern and Southern countries, but a negative relationship between overall annual mean temperature and agricultural production in Eastern and Southern countries, using a Cobb-Douglas production functional form. The negative link means that a rise in the yearly mean temperature of the countries causes a decline in agricultural productivity in Eastern and Southern countries.

Kumar and Managi (2016) used panel regression analysis to investigate the effects of climatic and non-climatic factors on food grain yield in thirteen Indian states from 1980 to 2009. The study discovered that average maximum temperature has a detrimental impact on the production of rice and maize crops. The claim that climate change affects agricultural irrigation via reducing water bodies can be used to explain this detrimental impact. Deressa, Hassan, and Poonyth (2005) used a Ricardian model to examine the influence of climate change on South African Sugarcane production under irrigated and dryland circumstances in their study. The study used time series data from 11 districts spanning the years 1977 to 1998. The findings revealed that climate change had a strong nonlinear impact on net revenue per hectare of sugarcane in South Africa, with temperature sensitivity being higher than precipitation sensitivity. Irrigation did not appear to be a viable solution for reducing the effects of climate change on sugarcane output in South Africa. According to the findings, adaptation methods should pay specific attention to technology and management regimes that improve sugarcane tolerance to warmer temperatures during the winter, particularly during harvesting.

Stefanos, Nastis, Anastasios, and Fotios (2012) investigated the economic impacts of climate change on Greek agricultural productivity during the last three decades and discussed the implications for policymakers and agricultural research. Climate change has a considerable impact on agricultural output, according to empirical findings, farmers must adjust to the projected implications of climate change in order to preserve their quality of living. Crop restructuring and changes in cultivation practices are all part of agriculture's adaptation to climate change. Policies must consider the multifaceted nature of modern agriculture as well as the need for long-term agricultural development. Arndt, Chinowsky, Robinson, Strzepek, Tarp, and Thurlow (2012) concentrated their analyses on research papers that took a bottom-up approach to assessing the economic effects of climate change. Much of the research backs up the long-held belief that developing countries are the most sensitive to the negative effects of climate change. They argued in one of their arguments that, while the agricultural sector is a high priority in climate change studies, climate change consequences are likely to affect other sectors and infrastructural development in an economy, not just the agricultural sector.

According to Calzadilla et al. (2014), as a result of climate change, South Africa is projected to face greater temperatures and less rainfall. Changes in regional water endowments and soil moisture will have an impact on farmland productivity, resulting in shifts in food production and worldwide trade patterns. South Africa's natural resources and food security may be further strained as a result of population increase elsewhere in Africa and Asia. This study evaluates the possible implications of climate change on world agriculture and explores two alternative adaptation scenarios for South Africa based on four climate change scenarios using two general circulation models (CSIRO and MIROC) and two IPCC SRES emission scenarios (A1B, B1). The study used an improved GTAP-W model that distinguishes between rainfed and irrigated agriculture and incorporates water as an explicit factor of production in the latter. To adapt to the negative effects of global climate change, South Africa would need to increase yields by more than 20% over baseline spending in agricultural research and development. A doubling of irrigation development, on the other hand, will not be enough to mitigate the country's negative effects from climate change.

Zwane (2019) examined the influence of climate change on primary agriculture, water supplies, and food security in the Western Cape, South Africa, in his study titled "Impact of Climate Change on Primary Agriculture, Water Sources, and Food Security in Western Cape, South Africa". The report is based on a review of the literature. To supplement the local experience about the impact of climate change on agriculture, a range of literature reviews were read, including 11 government papers and 21 journal articles that included experience from outside the Western Cape. According to the findings, numerous dams had low water levels (40 percent) in 2016/2017, resulting in lower crop harvests, particularly grapes. Droughts have become a recurrent occurrence, affecting both smallholder and commercial farmers. Small stock, beef, and dairy industries have been the hardest hit by the reduction in livestock production. The report finishes by outlining climate adaptation and mitigation measures and strategies in the Western Cape for both agricultural and livestock production. Scaling up the use of organic matter to avoid burning and creating gas emissions into the atmosphere, the effective use of livestock manure and the use of appropriate and adaptable seed varieties, managing livestock manure to assist in mulching to reduce water loss through evaporation, and the use of adaptable seeds were among the major recommendations.

Fazal and Wahab (2013) found that the agricultural sector is the most vulnerable to extreme climatic changes in their study of the economic impacts of climate change on the agricultural sector. Floods and droughts are the most common phenomena or disasters in extreme weather, according to the study. Climate change will have an impact on the ability of victims and affected states to maintain food supplies as a result of this condition. Masipa (2017) investigated the influence of climate change on food security in South Africa in a paper. The article used a desk study approach to accomplish this. Climate change and food (in)security have been the subject of previous research, reports, surveys, and legislation. Climate change poses a substantial risk to food security in Sub-Saharan African countries, according to this paper's study, from crop production to food distribution and consumption. As a result, it has been discovered that climate change, particularly global warming, has an impact on food security by affecting food supply, accessibility, use, and affordability. To reduce these threats, an integrated policy approach to safeguard arable land from global warming is required. The argument made in this article is that understanding of risks and the vulnerability of specific food items to climate change is critical to South Africa's ability to adapt and protect its food. However, because developing countries, such as South Africa, have weak institutions and limited access to technology, this offers a dilemma. Another source of concern is the large disparity between the expense of adaptation and the government's required financial assistance. It's also important to invest in technologies that can withstand threats to food systems.

In the study of Delince, Ciaian and Witzke (2015), the economic impacts of climate change on agriculture were examined within a time frame of 2005 to 2050. The study used the Agricultural Model Intercomparison and Improvement Project (AgMIP) approach to investigate the long-term global impacts on crop productivity under different scenarios. The paper provides horizontal model intercomparison from 11 economic models as well as a more detailed analysis of the simulated effects from the Common Agricultural Policy Regionalized Impact (CAPRI) model to systematically compare its performance with other AgMIP models. The findings reveal that at the global level, climate change tend to have a negative relationship with Agricultural productivity such that an increase in climate change will indicate a decrease in Agricultural productivity between -2% and -15% by 2050 while an increase in climate change will cause the price of food to increase between 1.3% and 56% and an expansion of cultivated area (between 1% and 4%) by 2050.

In his work on climate change impacts and responses in Nigeria, Haider (2019) claimed in accordance with his review that rising temperatures can cause reduced agricultural output and, as a result, have an adverse influence on Gross Domestic Product (GDP). The major goal of the research carried out by Maponya and Mpandeli (2012) was to determine the effects of climate variability and change on agricultural production in South Africa's Limpopo area. The study included 300 farmers ranging in age from 16 to 65 years old (46 percent men and 54 percent women). The impact of climate fluctuation and change on agricultural productivity was determined using statistics. Different adaptation techniques against colds, heat, frost, anomalous wind, hail, lack of extension assistance, nematodes, insecticides, worms, temperature, and rainfall, among other major adaptation alternatives utilized by farmers, were also reviewed in this research. Given the challenges that climate change poses to climate-sensitive sectors, the findings of this article could be useful to the agriculture industry.

Another piece of empirical study comes from Kahn, Mohaddes, Pesaran, Raissi, and Yang's (2021) cross-country study of climate change's long-term macroeconomic effects. This study discovered that prolonged fluctuations in temperature have a negative impact on economic development proxies such as real production growth, using a panel data set of 174 nations from 1960 to 2014. Furthermore, the research looked at whether temperatures in the United States' 48 states had risen between 1963 and 2016. According to the findings, the temperature in all 48 states has risen statistically significantly over time. The agriculture sector, in particular, is negatively impacted by temperature rise, according to the long-run sectoral effects estimation.

Subramaniam, Tajul, and Thirunaukarasu (2020) said that while the globe produces enough food to feed everyone, the number of people who go hungry remains high, particularly in underdeveloped countries. The relevance of institutions as a basis for the issue of food security may be highlighted by this subject. As a result, this research looks into the impact of institutions on food supply in a group of 56 developing countries. The results of the dynamic generalized techniques of moments show that institutional factors are important in increasing food availability and access to nutritious food for all people, therefore alleviating the food supply problem. As a result, the overall finding implies that policymakers should work to improve institutional quality so that it can serve as the foundation for reducing hunger and increasing food availability.

The impact of climate change on the total growth of the Nigerian economy was investigated by Ogbuabor and Egwuchukwu (2017). On a time-series data set spanning 1981 to 2014, the study used the OLS estimation approach. According to the findings, carbon emissions have a negative impact on both long-term and short-term economic growth. In the short run, forest loss, which was also included in the model as a proxy for climate change, revealed a negative connection with growth. The empirical analysis by Oloruntuyi and Adigun (2017) used a Descriptive and Error Correction Model. The study used a time series data set from 1970 to 2014 to assess the length of harm that climate changes in Nigeria provide to agricultural productivity. According to the research, temperature change is minor at 5% and has a negative impact on agricultural productivity. In summary, the study found that while temperature (one of the variables used to capture climate change) had no effect on agricultural output, rainfall (the other variable used to capture climate change) has a strong positive association with agricultural output.

In addition to the empirical studies on climate change, Alehile (2018) conducted an investigation to determine the impact of climate change on the performance of the Nigerian economy. An Autoregressive Distributed Lag (ARDL) model with an OLS estimate technique was used to conduct the research from 1990 to 2017. In the model, it was discovered that there is a long-term association. Climate change (as measured by temperature and precipitation data) was shown to be inversely associated with economic growth, according to the findings of the estimation. This negative association emphasizes the threat that climate change poses to Nigeria's economic success. As a result, the study advocated for a climate-friendly approach to industrial practices.

In a more recent study, Aderinto et al. (2021) conducted a research on the impact of institutional quality on agricultural sector performance in Nigeria. The Co-integration and Error Correction Mechanism (ECM) technique was used to analyze annual time series data from 1981 to 2018. The Statistical Bulletin of the Central Bank of Nigeria (CBN) and the Political Risk Service Database were used to compile the data. The findings demonstrated a negative correlation between agricultural productivity and the Institutional Quality proxy, as well as Bureaucratic Quality and Corruption. The study concludes that improving institutions will lead to improved agricultural performance in Nigeria.

Summarily, from a broad spectrum, many scholars have contributed to the study of climate change and institutional quality, but only a handful of available contributions explicitly concentrated on the cross elasticity of climate change, institutional quality and agricultural productivity. Amongst the explicit studies, there is a dearth of information which this empirical work satisfies. To begin with, earlier research focused on a disaggregated form of climate change, primarily capturing climate change through carbon emissions (CO_2). Although carbon dioxide (CO_2) accounts for the majority of anthropogenic gaseous activities in an economy, other gases such as methane (CH_4) and, in particular, nitrous oxide (NO_2) are also GHGs. Simply said, earlier research treated NO_2 and NH_4 as if they didn't exist. An aggregated version of climate change Emission level (a colligation or addition of atmospheric GH-gases released) will be utilized to close this gap in capturing climate change. The economic impact of this is that it would give a more accurate assessment on the impact of climate change on agricultural productivity as more important greenhouse gases are being captured in this literature. Table 1 shows the summary of the Literature Review.

Table 1. Summary of the Literature Review (Source: Author's construct).

Author/ Year	Scope	Methodology	Outcome
Gornall et al. (2010)		Descriptive	Climate change's effect on global agricultural productivity cannot be quantified.
Belloumi (2014)	11 Eastern and Southern African countries, 1961 to 2011.	Fixed effect country level panel analysis	A rise in the yearly mean temperature of the countries causes a decline in agricultural productivity
Kumar and Managi (2016)	13 Indian states, 1980 to 2009	Panel regression analysis	Average maximum temperature has a detrimental impact on the production of rice and maize crops
Deressa, Hassan, and Poonyth (2005)	11 districts in South Africa, 1977 to 1998	Ricardian model, Time series data	Climate change had a strong nonlinear impact on net revenue per hectare of sugarcane, with temperature sensitivity being higher than precipitation sensitivity.
Stefanos, Nastis, Anastasios, and Fotios (2012)	Greece, previous 3 decades	Time series	Climate change has a considerable impact on agricultural output.
Arndt, Chinowsky, Robinson, Strzepek, Tarp, and Thurlow (2012)	Research papers that took a bottom-up approach to assessing the economic effects of climate change.	Literature Review/ Meta study	Agricultural sector of high priority in climate studies but not exclusively impacted.
Calzadilla et al (2014)	South Africa	GTAP-W model that distinguishes between rainfed and irrigated agriculture and incorporates water as an explicit factor of production in the latter.	To adapt to the negative effects of global climate change, South Africa would need to increase yields by more than 20% over baseline spending in agricultural research and development. A doubling of irrigation development will not be enough to mitigate the country's negative effects from climate change.
Zwane (2019)	11 government papers and 21 journal articles that included experience from outside the Western Cape.	Literature Review/ Meta Study	Numerous dams had low water levels (40 percent) in 2016/2017, resulting in lower crop harvests, particularly grapes. Droughts have become a recurrent occurrence, affecting both smallholder and commercial farmers. Small stock, beef, and dairy industries have been the hardest hit by the reduction in livestock production.
Fazal and Wahab (2013)		Literature Review/ Meta Study	The agricultural sector is the most vulnerable to extreme climatic changes
Masipa (2017)		Desk study	Climate change, particularly global warming, has an impact on food

			security by affecting food supply, accessibility, use, and affordability.
Delince, Ciaian and Witzke (2015)	2005 to 2050	Agricultural Model Intercomparison and Improvement Project (AgMIP) approach. Horizontal model intercomparison from 11 economic models. Common Agricultural Policy Regionalized Impact (CAPRI) model.	At the global level, climate change tend to have a negative relationship with Agricultural productivity such that an increase in climate change will indicate a decrease in Agricultural productivity between -2% and -15% by 2050 while an increase in climate change will cause the price of food to increase between 1.3% and 56% and an expansion of cultivated area (between 1% and 4%) by 2050
Haider (2019)	Nigeria	Literature Review	Rising temperatures can cause reduced agricultural output and, as a result, have an adverse influence on Gross Domestic Product (GDP).
Maponya and Mpandeli (2012)	South Africa's Limpopo area. 300 farmers ranging in age from 16 to 65 years old (46 percent men and 54 percent women).	Cross Sectional and Descriptive Analysis	Climate fluctuation affects change on agricultural productivity. Farmer's adapt to Climate change.
Kahn, Mohaddes, Pesaran, Raissi, and Yang's (2019)	174 nations from 1960 to 2014. United States' 48 states 1963 and 2016.	Panel Analysis	Prolonged fluctuations in temperature have a negative impact on economic development proxies such as real production growth. The temperature in all 48 states has risen statistically significantly over time. The agriculture sector, in particular, is negatively impacted by temperature rise.
Subramaniam, Tajul, and Thirunaukarasu (2020)	56 developing countries.	Dynamic generalized techniques of moments	Institutional factors are important in increasing food availability and access to nutritious food for all people.
Ogbuabor and Egwuchukwu (2017)	Nigeria, 1981 to 2014.	OLS estimation approach.	Carbon emissions have a negative impact on both long-term and short-term economic growth.
Oloruntuyi and Adigun (2017)	Nigeria, 1970 to 2014.	Descriptive and Error Correction Model.	Temperature change is minor at 5% and has a negative impact on agricultural productivity. Raiinfall (the other variable used to capture climate change) has a strong positive association with agricultural output.
Alehile (2018)	Nigeria, 1990 to 2017.	Autoregressive Distributed Lag (ARDL) model with an OLS estimation technique	Climate change (as measured by temperature and precipitation data) was shown to be inversely associated with economic growth.
Aderinto et al. (2021)	Nigeria, 1981 to 2018.	The Co-integration and Error Correction Mechanism (ECM) technique's	A negative correlation between agricultural productivity and the Institutional Quality proxy, as well as Bureaucratic Quality and Corruption.

3. Methodology

3.1. Theoretical Framework

This empirical investigation is based on the production function idea. The output or productivity of a business is determined by a mix of inputs, according to the production function principle. When the levels of inputs are changed, the output level will imply that the output level will change as well. The Cobb-Douglas production function, created by Charles-Cobb and Paul Douglas, is a well-known type of production function. Output (Q) is expressed as a quadratic function of labor and physical capital inputs in the Cobb-Douglas production function.

It is mathematically represented as $Q = AL^{\alpha}K^{\beta}$

Where:

L = Labour input K = Physical capital input

A = Functional operator α and β = Parameters.

By taking the natural logarithm of the equation, the existing quadratic relationship in the Cobb-Douglas principle can be linearized. Agricultural productivity is also expressed as a function of numerous input parameters in this study, including agricultural land, gross fixed capital formation, real gross domestic product, emission level, mean rainfall emission ratio, and non-oil export. As a result, the required frameworks are expressed in the parts that follow.

3.2. Model Specification

To minimize specification bias or specification error, Occam's principle states that a model should be specified parsimoniously. To that purpose, this study will adequately specify the model in accordance with the objectives of the study.

Model:

$LAO = \beta_0 + \beta_1 LEML + \beta_2 LFDI + \beta_3 INFL + \beta_4 M2 + \beta_5 MAR + \beta_6 MAT + \beta_7 REQ + \beta_8 RUL + \mu_t$………………(1)

Where:

β_0 = the intercept term.

$\beta_1 – \beta_7$ = the parameters of the respective independent variables in model 1.

μ = stochastic term

LAO = **Log of Real Agricultural Output:** Real agricultural output is a component of real gross domestic product. This implies that it is the value of all final goods and services related to the agricultural sector in the economy. In this study, real agricultural output is used to proxy agricultural productivity since basically, it presumptively captures the entire agricultural activities in the economy. LEML = **Emissions Level:** Emissions level is the level of greenhouse gases present in the atmosphere at a particular period. It involves gases from both anthropogenic and natural related activities. Emissions level is measured in kilotonnes and it is calculated as the summation of major greenhouse gases which are Carbon-dioxide (CO_2), Nitrogen dioxide (NO_2), and Methane (CH_4). Emissions level is used in this study because it captures major gases that constitute to the thickening of plants' leaves, the warming of the atmosphere and the consequent of change of the climate. LFDI = **Foreign Direct Investment:** Foreign direct investment refers to direct investment equity flows in the economy. It is the sum of equity capital, reinvestment of earnings, and other capital. FDI is an important channel for the transfer of technology between countries, promotes international trade through access to foreign markets, and can be an important vehicle for economic growth and development. INFL=**Inflation:** Inflation is a rise in prices, which can be translated as the decline of purchasing power over time. The rate at which purchasing power drops can be reflected in the average price increase of a basket of selected goods and services over some time. The rise in prices, which is often expressed as a percentage, means that a unit of currency effectively buys less than it did in prior periods. M2 = **Broad Money Supply (M2):** Broad money is a category for measuring the amount of money circulating in an economy. It is defined as the most inclusive method of calculating a given country's money supply, and includes narrow money along with other assets that can be easily converted into cash to buy goods and services. MAR = **Mean Annual Rainfall:** Mean annual rainfall means the average of the annual amount of precipitation for a location over a year as measured by the nearest National Weather Service station for the preceding three decades. MAT = **Mean Annual Temperature:** The mean annual temperature refers to the average of the maximum and minimum temperatures of a year, taking the mean average of the coldest month of the year and averaging it with the mean average of the hottest month of the year. REQ = **Regulatory Quality:** Regulatory quality indicator captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. In regulatory quality, the performance score ranges from 0 to 100. The highest score reflects the best situation. In this study, regulatory quality is one of the variables used to proxy institutional quality. RUL = **Rule of Law:** This indicator measures the extent to which individuals and firms have confidence in and abide by the rules of society, in particular, it measures the functioning and independence of the judiciary, including the police, the protection of property rights, the quality of contract enforcement, as well as the likelihood of crime and violence. The rule of law is a practice, or norm that supports the equality of all citizens before the law, secures a non arbitrary form of government, and more generally prevents the arbitrary use of power. In this study, rule of law is one of the variables used to proxy institutional quality.

3.3. Estimation Technique

An evaluation of the method includes checking whether the estimated coefficients conform to theory and are statistically satisfactory. Since the regression analysis is a multiple regression analysis the Ordinary Least Squares method is used because of its BLUE (Best Linear Unbiased Estimator) properties.

3.4. Nature and Sources of Data

This study employs bi-annual secondary time series data that spans from 1996 to 2020. Data for this study are sourced from CBN statistical bulletin, World Bank Development Indicators (WDI) and World Bank Climate Change Knowledge Portal.

4. Results and Discussion

4.1. Descriptive Statistics of the Variables

Table 1 gives face-value information about the measures of cluster, dispersion and variability of the variables under consideration. The mean values of 9.2181 and 12.4576 show the respective average values or expected observations of the logged agricultural output and emissions level in Nigeria over the time-span of study. This interpretation is akin to that of other variables in line with their respective mean values, except for INFL and REQ. The difference between the maximum values and minimum across the data set will yield the range. By arithmetic intuition, the table does not suggest the presence of outlier in the data set. The standard deviations as well indicate that the variables exhibit some variations and also, about four variables from the data set are negatively skewed.

Table 2 below suggests that all the variables were normally distributed following the insignificant p-values of the jarque-bera statistic, except from INFL and REQ at the 5% level of significance. This can be traced to positive outliers in the case of INFL and negative outliers in the case of REQ as can be traced from the Skewness statistic. This depicts the high inflation rates as well as low regulatory quality experienced by Nigeria in the period considered.

Table 2. Descriptive Statistics of the Variables (Source: Authors' Construct).

	LOG(AO)	LOG(EML)	LOG(FDI)	INFL	M2	MAR	MAT	REQ	RUL
Mean	9.2181	12.4575	21.6322	12.36	18.7436	1164.17	27.3276	−0.9094	−1.1475
Median	9.3626	12.4343	21.6041	12.0947	21.3558	1163.22	27.36	−0.8987	−1.1561
Maximum	9.8172	12.6384	22.9026	29.2682	27.3787	1269.15	27.81	−0.6818	−0.826
Minimum	8.3268	12.3137	19.5178	5.388	9.0633	1027.38	26.85	−1.2928	−1.5125
Std. Dev.	0.5074	0.0987	0.9632	4.9351	6.171	64.5827	0.2299	0.152	0.1826
Skewness	−0.5928	0.3905	−0.5423	1.5104	−0.2058	−0.4755	0.0686	−0.8619	−0.2983
Kurtosis	1.9218	1.9156	2.3184	6.3531	1.3835	2.5489	2.7457	3.5154	2.5112
JB (Jarque–Bera)	5.3509	3.7204	3.4186	42.4354	5.7962	2.3083	0.1739	6.7436	1.2391
Prob (Probability)	0.0688	0.1556	0.1809	0.0000	0.0551	0.3153	0.9166	0.0343	0.5381
Obs (Observations)	50	50	50	50	50	50	50	50	50

4.2. Descriptive Graphs of the Variables

In Figure 4, log of agricultural output and log of emissions level show on an average, an upward continuous growth. The growth path suggests a similar scenario in the flow of rule of law as evident in the table. Mean annual temperature and rule of law in their own trend exemplify a jerk-like movement across the period under study.

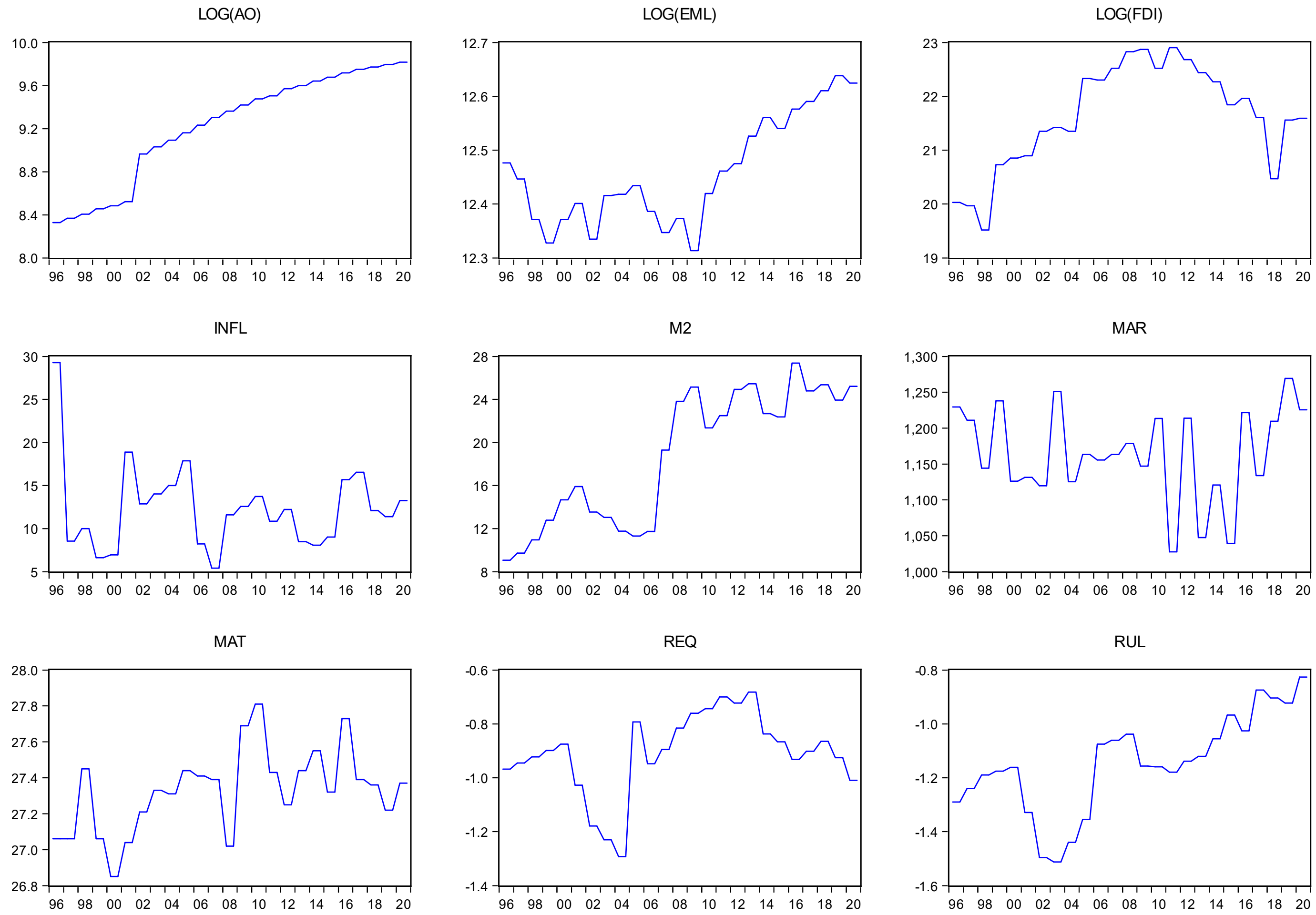

Figure 4. Descriptive graph of the variables.

4.3. Pre-estimation Test Results

4.3.1. Unit Root Test (Battery Test)

The results of the ADF's unit root test, shown in Table 3 below, reveal that all the variables are stationary and have no unit root. Specifically, LAO, INFL and RUL are stationary at levels whereas the other variables are stationary after being differenced once. This probably indicates co-integration as well as a dynamic interaction between the variables. The observation of the order of stationarity in the above result satisfies the condition upon which this study was conducted.

Table 3. Unit Root Result AIC (Trend & Intercept. Source: Authors' Construct).

Variables	Level Form @5%			First Difference @5%			Order of Stationarity
	ADF t-statistic	Critical Value	P-Value	ADF t-statistic	Critical Value	P-Value	
LAO	−16.9818	−3.6736	0.0001				I(0)
LEML	−2.7111	−3.6121	0.2410	−5.4010	−3.6220	0.0012	I(1)

LFDI	−1.4113	−3.6121	0.8311	−6.6114	−3.6328	0.0001	I(1)
INFL	−6.1587	−3.6121	0.0002				I(0)
M2	−2.8482	−3.6220	0.1958	−4.0296	−3.6220	0.0223	I(1)
MAR	−1.6885	−3.6220	0.7234	−12.9782	−3.6220	0.0000	I(1)
MAT	−3.8742	−3.6121	0.0297	−4.7664	−3.6908	0.0070	I(1)
RUL	−3.6987	−3.6449	0.0452				I(0)
REQ	−2.0487	−3.6121	0.5466	−5.4449	−3.6220	0.0011	I(1)

4.3.2. Co-integration Test Results

Since not all the variables are stationary at level, a co-integration test is carried out using the Johansen procedure still taking into account trend and intercept. The above table shows the co-integration test results which is used to check if there is a long run relationship among the variables in the model. From the result above, the asterisks under the co-integrating equations column shows that there exists co-integration. Since from the above results there are four (4) asterisks, this reveals at least four significant co-integrating equations which shows that there exists a long-run relationship among the variables in the model. Table 4 shows the Johansen Co-Integration Test Results, while Table 5 shows the OLS Long Run Model Regression Result.

Table 4. Johansen Co-Integration Test Results (Source: Authors' Computation).

No. of Cointegrating Equations	Trace statistic	0.05 Critical Value	P-Value
None *	380.5047	228.2979	0.0001
At most 1 *	263.5625	187.4701	0.0000
At most 2 *	185.0445	150.5585	0.0001
At most 3 *	121.1436	117.7082	0.0298
At most 4	86.7557	88.8038	0.0696
At most 5	57.0423	63.8761	0.1643
At most 6	32.2434	42.9152	0.3754
At most 7	18.5765	25.8721	0.3065
At most 8	6.7165	12.5179	0.3750

* shows a co-integrating equating at 5%.

Hence, a co-integrating equation is significant if the Trace Statistics is greater than the 5% critical value or the P-value is less than or equal to 0.05 level of significance.

4.4. Long Run Model Regression Result

Table 5. OLS Regression Result (Dependent Variable: LAO. Source: Authors' Computation from E-views 9.0).

Variable	Coefficient	STD. Error	T-Statistic	Prob. Value
LEML	2.1183	0.2889	7.3320	0.0000
LFDI	0.2586	0.0282	9.1510	0.0000
INFL	−0.0081	0.0043	−1.8959	0.0650
M2	0.0224	0.0057	3.8827	0.0004
MAR	−0.0001	0.0003	−0.2540	0.8008
MAT	0.3950	0.0899	4.3923	0.0001
REQ	−0.7348	0.1535	−4.7855	0.0000
RUL	0.3615	0.1836	1.9681	0.0558
C (constant term)	−34.0439	4.2133	−8.0800	0.0000

R^2 = 0.951176; Adj. R^2 = 0.941650; F-statistic = 99.84457; Prob (F-statistic) = 0.000000; D-W Stat. = 1.043102

4.5. Evaluation of Results

4.5.1. Evaluation Based on Economic Criteria (A Priori)

In this section, the regression result is evaluated based on theoretical assumptions, signs and magnitude of the estimated parameters.

The constant term (C) in the regression result as shown in Table 5 has a value of −34.0439, indicating that when all other explanatory variables are held constant, LAO will fall by 34.0439.

The coefficient of log of emissions level is 2.1183, suggesting that emissions level has a positive relationship with agricultural output. This coefficient, as evident from the result, is also statistically significant. Therefore, holding other variables constant, a unit increase in the emission levels leads to about 2.11% increase in agricultural output in the long run. This result does not conform to a priori expectation. NASA (2016) has shown that higher concentrations of atmospheric carbon dioxide affect crops in two important ways: they boost crop yields by increasing the rate of photosynthesis, which spurs growth, and they reduce the amount of water crops lose through transpiration. Plants transpire through their leaves, which contain tiny pores called stomata that open and collect carbon dioxide molecules for photosynthesis. During that process, they release water vapor. As carbon dioxide concentrations increase, the pores don't open as wide, resulting in lower levels of transpiration by plants and thus increased water-use efficiency. This is a possible explanation for the result we have. Overall, the relationship environment, emissions levels and agricultural output are complex and depend on a variety of factors (Okolo, et al. 2024 and Anthony-Orji, et al., 2023). It is important to consider the potential impacts of emissions on both the environment and agriculture when making decisions about emissions levels.

From the regression result above, the coefficient of log of foreign direct investment is 0.2586. The statistically significant coefficient at the conventional 5% level of significance shows a positive relationship between foreign direct investment and agricultural output. Thus, all other variables held constant, on average, an increase in foreign direct investment will cause agricultural output to increase by 0.25% in the long-run which increases economic growth in Nigeria. Interestingly, this conforms to a priori expectation. This is because it is anticipated that foreign investors will tend to channel funds to the agricultural sector so as to reap the benefits of the unharnessed potentials in the sector and by doing so maximise returns from investment. This is also in consonance with empirical findings from Popoola, Obindah and Urhie (2017).

The coefficient of inflation is −0.0081, implying a negative relationship between agricultural output and inflation. So that on average, and holding other variables constant, a percentage increase in inflation leads to about 0.8ure1% decrease in agricultural output in the long-run which affects economic growth positively. This effect is not statistically significant at 5% level of significance, it still conforms to a priori expectation of the study. When inflation occurs, the purchasing power of money decreases, which means that a unit of currency can buy fewer goods and services. In the case of agricultural output, there are a few ways in which inflation could lead to a decrease:

1. Increased production costs: Inflation can lead to an increase in the cost of inputs such as seeds, fertilizers, and fuel, which can make it more expensive for farmers to produce crops. This could lead to a decrease in the quantity of crops that farmers are able to produce.
2. Decreased profitability: If the price of agricultural products does not increase at the same rate as the cost of production, farmers may not be able to sell their crops at a profit. This could lead to a decrease in the quantity of crops that farmers are willing to produce.
3. Decreased demand: If the general price level of goods and services increases, people may have less disposable income to spend on non-essential items such as food. This could lead to a decrease in the demand for agricultural products, which could in turn lead to a decrease in the quantity of crops that farmers are able to sell.

The coefficient of broad money supply from the result above is 0.0224. This value implies the existence of a positive relationship between broad money supply and agricultural output which is statistically insignificant at 5% level of significance. This shows that a percentage increase in the broad money supply will cause a significant increase to the agricultural output by 0.22%. This conforms to economic theory. An increase in the money supply can lead to an increase in agricultural output if it results in increased demand for agricultural products. This can happen in a number of ways. For example, if the increase in the money supply leads to lower interest rates, it may encourage more borrowing and spending, which can increase demand for agricultural products. Additionally, if the increase in the money supply leads to higher levels of economic growth, it may also increase demand for agricultural products. It's worth noting that there are other factors that can affect agricultural output as well, such as technological advances, changes in weather and climate, and changes in government policies. Additionally, the relationship between the money supply and agricultural output can vary depending on the specific circumstances of a given country or region.

From the result above, the coefficient of mean annual rainfall is −0.0000762. This implies that there exists a negative relationship between mean annual rainfall and agricultural output. Hence, a percentage increase in mean annual rainfall will cause agricultural output to decrease by 0.000762%. This effect is not statistically significant at 5% level of significance and does not conform to a priori expectation. In most cases, rainfall is a critical factor in plant growth and the production of crops, and a decrease in rainfall can lead to reduced crop yields. However, there are some circumstances in which a decrease in rainfall could potentially lead to an increase in agricultural output. For example:

1. If the decrease in rainfall is accompanied by a decrease in the amount of water lost through evaporation (such as in the case of a cooler, more humid climate), this could result in more water being available for plants to use, potentially leading to increased crop yields.
2. If the decrease in rainfall is accompanied by an increase in the use of irrigation systems, this could also potentially lead to increased crop yields.
3. In some cases, a decrease in rainfall may lead to an increase in the use of drought-resistant crop varieties, which can be more resistant to dry conditions and may be able to produce higher yields under these conditions.

From the result above, the coefficient of mean annual temperature is 0.3950. This implies that there exists a positive relationship between mean annual temperature and agricultural output. Hence, a percentage increase in mean annual temperature will cause agricultural output to increase by 0.39%. This effect is statistically significant at 5% level of significance and does not conform to a priori expectation. Here are some ways in which an increase in temperature can lead to increased agricultural output: higher temperatures can lead to faster plant growth, which can result in increased crop yields, warmer temperatures can also extend the growing season for some crops allowing for more time for plants to grow and produce crops and an increase in temperature can also lead to an increase in the availability of water for plants, as warmer temperatures can lead to increased evaporation and precipitation.

From the result above, the coefficient of regulatory quality is −0.7348. This implies that there exists a negative relationship between regulatory quality and agricultural output. Hence, a percentage increase in regulatory quality will cause agricultural output to decrease by 0.73%. This effect is statistically significant at 5% level of significance and does not conform to a priori expectation. This could be a result of non-compliance with regulatory quality standards by agriculturists. Another example concerns informality. In general, when the cost of compliance is higher than the benefits of compliance farmers are motivated not to comply with these regulations. As agricultural production involves less complex processes than services or manufacturing, legal protection and contract enforcement become less valuable. Consequently, firms in agriculture are more sensitive to regulations with high costs of compliance, and consequently more prone to avoiding them by remaining (or becoming) informal (Loayza, Servén and Sugawara 2009). Also, due to agriculture's importance for human health and food security, political stability and environmental sustainability, it is not unusual for governments to implement more stringent agricultural regulations (Diaz-Bonilla 2014). Reduced bureaucracy and red tape also come into play here. If regulatory processes are streamlined and made more efficient, it may be easier for farmers to access credit, land, and other resources needed to improve their operations and productivity. A decrease in regulatory quality can also lead to increased competition in the agriculture sector, as it may be easier for new entrants to enter the market. This can drive innovation and efficiency, leading to increased productivity. Greater access to new technologies: A more open and flexible regulatory environment may also facilitate the adoption of new technologies, such as precision farming techniques, that can increase productivity.

From the result above, the coefficient of rule of law is 0.3615. This implies that there exists a positive relationship between rule of law and agricultural output. Hence, a percentage increase in rule of law will cause agricultural output to increase by 0.36%. This effect is not statistically significant at 5% level of significance and conforms to a priori expectation. These law deals with legal matters concerning the agricultural sector, such as agricultural infrastructure, seed, water, fertilizers, pesticides agricultural finance, agricultural insurance, farming rights and tenure systems and the legal regulations used in agro processing and rural industries. Law has a very vital role to play in agricultural production. As explained below, law contributes to agricultural production in the following ways: acquisition of land, land use and management, guaranteed prices and markets, agricultural insurance and financing, agro processing and rural industries development, environmental protection and sustainable development. It is indeed evident that the law is very vital in agricultural production as it provides farmers with good legal environment for cultivation. However, it is said that the law is a double-edged sword, therefore as much as the law protects the farmer, it should not be violated, as they will face full force of the law.

In the result of Table 4 above, R^2 is 0.9511. This means that the explanatory variables used in the model account for about 95.1% variation in the explained or dependent variable. This passes the goodness of fit test. Hence, the model is robust. Also, from Table 4 above, adjusted R^2 is 0.9416. This shows that the model is parsimoniously selected. Hence, Occam's razor or the principle of parsimony applies thereby making the model robust.

4.5.2. Multicollinearity Test Result

To check the problem associated with multicollinearity, correlation analysis is undertaken to investigate the degree of association among the independent variables. A correlation coefficient of 0.8 and above indicates the presence of multicollinearity. Therefore, in Table 6, only LAO and M2 had a correlation of up to 0.8. Nevertheless, according to Blanchard (1987), this does not constitute much problems to the regression analysis. According to him, multicollinearity is God's will and not a problem of statistical techniques in general. Hence, we do nothing.

Table 6. Correlation Matrix Result – Model 1 (Source: Authors' Construct).

	LAO	LEML	LFDI	INFL	M2	MAR	MAT	REQ	RUL
LAO	1								
LEML	0.6371	1							
LFDI	0.6696	−0.0105	1						

INFL	−0.1490	0.1656	−0.2087	1					
M2	0.8565	0.5584	0.5732	−0.1706	1				
MAR	−0.1029	0.1154	−0.2813	0.2451	−0.1002	1			
MAT	0.5795	0.2018	0.4708	−0.0220	0.4332	−0.0874	1		
REQ	0.3225	0.1171	0.4568	−0.2422	0.5058	−0.2390	0.2694	1	
RUL	0.6211	0.6283	0.1839	−0.2770	0.7046	0.0539	0.1905	0.4809	1

4.5.3. Parameter Stability Test (CUSUM Test)

CUSUM tests of parameter stability plot recursively updated test statistics over time to see if any significant breaks in the statistics may be observed. The results of this test, shown in Figure 5 below, reveal that all of the estimated model's coefficients are stable over time within the critical boundaries of 5%. We can accept the model's results based on this stability test.

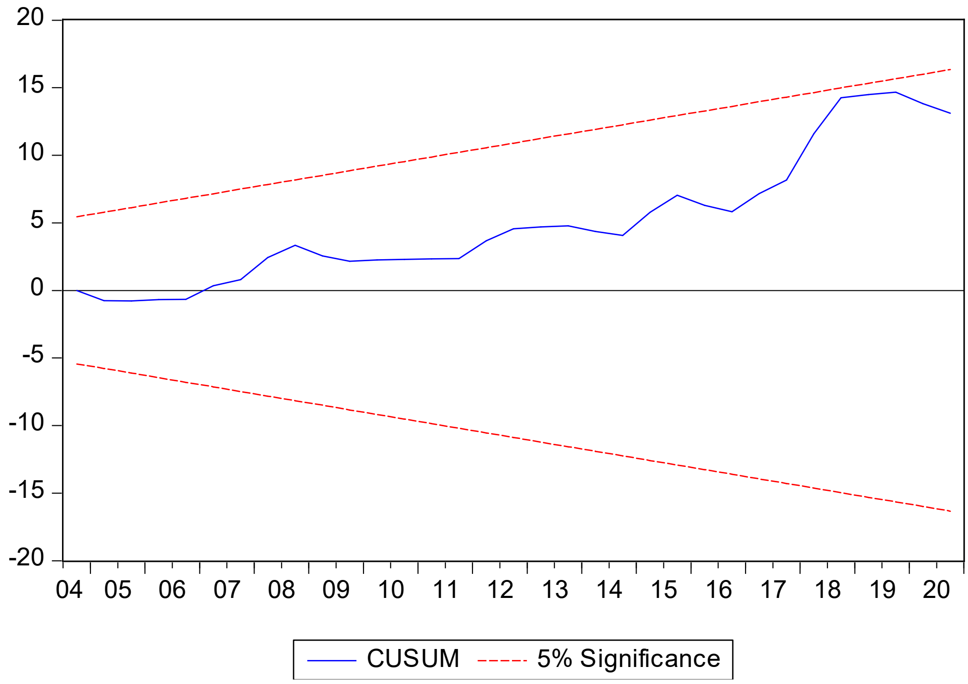

Figure 5. CUSUM Plots for Stability Test.

4.6. Evaluation of Research Hypotheses

To achieve the objectives of this study, two hypotheses are formulated in section one of this empirical study. This section evaluates each of the hypotheses as follows:

$H0_1$: Climate change has no significant impact on agricultural productivity in Nigeria.

In this study, climate change is proxied by emissions level, mean annual rainfall, and mean annual temperature. On the other hand, total agricultural output is proxied by real agricultural output. From the estimation output as presented in Table 4 above, the emissions level an average impact significantly on financial intermediation by about 2.11%, holding other variables constant. The result also revealed that the emissions level is positively related to agricultural output. Mean annual temperature also significantly impacts agricultural output, although positively. The regression output shows a coefficient of 0.395017.

$H0_2$: Institutional quality has no significant impact on agricultural productivity in Nigeria.

For this hypothesis, institutional quality variables are proxied by regulatory quality and the rule of law. Conversely, total agricultural output is proxied by real agricultural output. The estimation output in Table 4 reveals that Regulatory quality is statistically significant while the rule of law is statistically insignificant with coefficients of −0.734848 and 0.361503, respectively.

5. Policy Recommendations

This empirical study aims to broadly examine the relationship between climate change, institutional quality, and agricultural productivity in Nigeria using Ordinary Least Squares. It does so in response to the rising trends of greenhouse gases, the declining trends of agricultural output, the widespread flaring of carbon gases in Nigeria, the effects of extreme cold and heat, and the red alert by international organizations (such as IPCC, WMO) on climate change (OLS)

The results of this study reveal that institutional quality and climatic change have statistically significant effects on agricultural output yield in Nigeria. Additionally, it proves that there is a long-term connection between agricultural productivity, institutional quality, and climatic change.

Following the findings of this study, the following policy recommendations are made:

1. Regenerative Agriculture: This method is a cautious and remedial farming strategy that protects both the top soil and the food supply. Regenerative agriculture promotes environmentally friendly farming methods such as water reticulation, minimal tillage, grass-fed animals, biosequestration, waste recycling, repurposing of agricultural products, etc. These methods promote resilience to climate change while also enhancing soil health.
2. Emphasis on Climate Smart Agriculture: In order to prevent food shortages, climate smart agriculture is a strategy that combines numerous environmentally beneficial agricultural practices. Its three main goals are to raise agricultural productivity and revenue, adapt and strengthen crop resilience to climate change, and, finally, eliminate or limit flaring of greenhouse gases (GH-gases), particularly farm and agriculturally-induced flaring. Examples of these approaches include crop rotating practices, organic annual cropping, and mixed agricultural farming. According to this report, it is the responsibility of the Nigerian government, the Federal Ministry of Agriculture, private farmers, and stakeholders to promote these practices throughout the nation.
3. Investment in Agricultural Technology (Agro-Tech): The global world's future lies in technology. Traditional bush burning methods of clearing land for farming should no longer be promoted in Nigeria. Commercial farms could use equipment, robotics, and even energy-efficient planters for agricultural tasks. Small scale farmers can be gathered to make collectively

larger firms to properly benefit from the scheme.

4. Clean Growth and Low Carbon Growth Path: Simply said, clean growth is economic expansion accompanied by a reduction in carbon emissions. Nigeria must implement clean growth and low carbon growth practices and regulations, similar to the United Kingdom and the European region, to limit the influence of carbon emissions or emission level on climate change. Adoption of a green budget, carbon penalties and permits, green bonds, and, in short, a green economy are a few of these initiatives. These programs and tools respect the environment.
5. Capacity building: To increase institutional capacity, there should be frequent training and capacity building for the employees of the institutions associated with policy implementation, such as the CBN, banks, the Ministry of Agriculture, etc. Providing education and training programs for farmers can also help increase their knowledge and skills, which can lead to increased productivity. Providing extension services to farmers, such as training on modern farming techniques and access to technology, can help increase productivity.
6. Anti-corruption measures: Corruption exists in every nation. Governments with lower levels of corruption, however, would distribute resources more effectively and economically, with less bias. In order to prevent excessive corruption at all levels of administration in the agriculture sector, strict procedures should be implemented. The ability of bureaucracy to effectively help the agriculture industry is further weakened by corruption because efficient bureaucracy is anticipated in the relevant organizations. Agencies fighting against corruption should be independent as well as strengthened both constitutionally and financially.
7. Strengthening property rights and promoting research and development: Establishing clear property rights and land tenure can give farmers the security they need to invest in their land and increase productivity. Also, supporting research and development in agriculture can help improve crop yields.
8. Investment in infrastructure: Improving infrastructure, such as roads, irrigation systems, and storage facilities can help increase agricultural productivity. Improving infrastructure and transportation networks can help farmers get their products to market more efficiently, increasing their income and encouraging increased production.

6. Conclusion

Climate change is now and always a global phenomenon. Using a time span of 1996 to 2020, this study has contributed its own scheme to the few existing stock of literature on climate, institutions and agricultural practices. Findings have been made which corroborate the claim of very few previous studies. This can serve as a guidance for policy makers in policy initiation and formulation.

With full cognizance, from the findings of this study, policy suggestions have been made in order to advance a better course towards agricultural productivity and climate change reduction, better institutions. Hence, it is therefore the task of the government, private investors, stakeholders, scholars, policy makers and think-tanks, etc., to adopt or fine-tune the policy suggestions of this study to a more appropriate and workable plan for the Nigerian economy at large. A step in that direction would be the establishment of farm cooperatives in village communities to gather small holder farms along with contracts with Agricultural equipment manufacturers. Furthermore, agencies fighting against corruption should be independent as well as strengthened both constitutionally and financially.

Finally, future studies may observe interaction effects in institutional quality and climate change, additionally utilizing principal component analysis, institutional quality may be captured by a singular variable rather than the multiple variables used in this study.

Author contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used: Conceptualization, A.O. and O.E.K.; methodology, J.E.O.; software, O.E.K.; validation, A.O., NI and O.I.A.-O.; formal analysis, A.O. and O.E.K.; writing—original draft preparation, O.E.K.; writing—review and editing, A.O. All authors have read and agreed to the published version of the manuscript.

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References

Aderinto E., Ogunro T., & Ogunjinmi O. (2021). Institutional Quality and Agricultural Sector Performance in Nigeria. IAR Journal of Humanities and Social Science, 2(2).

Ajayi S. (2003, August 7–8). Institutions: The Missing Link in the Growth Process? Presidential Address Delivered at the 43rd Annual Conference of the Nigerian Economic Society. Lagos, Nigeria.

Alehile K.S. (2018). Climate change and economic performance in Nigeria. Nigerian Journal of Contemporary Public Policy, 12(1), 17–32.

Anthony-Orji O.I., Ideba E.T., Orji A., Duru E.E., Ifurueze P.C., Nwaimo C.E. and Amako J.C. (2023). Financial Inclusion and environmental Sustainability Nexus in ECOWAS: A New Empirical Evidence. Journal of Liaoning Technical University, 17(12), 48–64.

Ayinde O.E., Muchie M., & Olatunji G.B. (2011). Effect of climate change on agricultural productivity in Nigeria: A co-integration model approach. Journal of Human Ecology, 35(3), 189–194.

Belloumi M. (2014). Investigating the impact of climate change on agricultural production in eastern and southern African countries. International Food Policy Research Institute.

Calzadilla A., Zhu T., Rehdanz K., Tol R.S., Ringler C. (2014) Climate change and agriculture: Impacts and adaptation options in South Africa. Water Resources and Economics, 5, 24–48. https://doi.org/10.1016/j.wre.2014.03.001

Deressa T., Hassan R., & Poonyth D. (2005). Measuring the impact of climate change on South African agriculture: The case of sugarcane growing regions. Agrekon, 44(4), 524–542. https://doi.org/10.1080/03031853.2005.9523726

Diaz-Bonilla E., Orden D., and Kwiecinski A. (2014). Enabling environment for agricultural growth and competitiveness: Evaluation, indicators and indices. OECD publishing.

Ebele E.N., & Emodi V.N (2016). Climate change and its impact in Nigerian economy. Journal of Scientific Research & Reports, 10(6), 1–13.

Ekeocha D.O., Ogbuabor J.E., Ogbonna O.E. and Orji A. (2023). Economic policy uncertainty, governance institutions and economic performance in Africa: are there regional differences? Economic Change and Restructuring, 56, 1367–1431. https://doi.org/10.1007/s10644-022-09472-7

Ekpenyong U.I. & Ogbuagu M.I., (2015). Climate change and agricultural productivity in Nigeria: An Econometric Analysis. Available online: https://ssrn.com/abstract=2636868 (accessed on 6 April 2025).

Fazal S.A and Wahab S.A. (2013). Economic impact of climate change on Agricultural Sector: A review. Journal of Transformative Entrepreneurship, 1(1), 39–49.

FME (2015). Climate Smart Agriculture. Department of Climate Change. Federal Ministry of Environment.

Gelgo B., Gemechu A., & Bedemo A. (2023). The effect of institutional quality on agricultural value added in East Africa. Heliyon, 9(10), e20964–e20964. https://doi.org/10.1016/j.heliyon.2023.e20964

Gilad S. (2025). Institution political science. In Encyclopedia Britannica. Available online: https://www.britannica.com/topic/institution (accessed on 6 April 2025).

Haider H. (2019). Climate change in Nigeria: Impacts and responses. K4D Helpdesk Report 675. Brighton, UK: Institute of Development Studies.

Hodgson G.M. (2004). The evolution of institutional economics. Routledge.

IPCC (2007). Climate Change 2007: The Physical Science Basis. IPCC Cambridge University Press.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC Cambridge University Press.

IPCC (1998). The Regional Impact of Climate Change: An Assessment of Vulnerability. Special Report of IPCC working Group II. IPCC Cambridge University Press.

IPCC (2007). Climate change impacts, adaptation and vulnerability summary for policy makers (contribution of working Group II to the Fourth Assessment Report of the IPCC). IPCC Cambridge University Press.

Kahn M.E., Mohaddes K., Ryan N.C, Pesaran H.M., Ressi M., & Yang J.C. (2021). Long term macroeconomic effects of climate change: A cross-country Analysis. Energy Economics, 104, 105624. https://doi.org/10.1016/j.eneco.2021.105624

Kumar S. & Managi S. (2016). Carbon Sensitive Productivity, Climate and Institutions. Environment and Development Economics, 21(1), 109–133. https://doi.org/10.1017/S1355770X15000054

Maponya P., & Mpandeli S. (2012). Climate change and agricultural production in South Africa: Impacts and adaptation options. Journal of Agricultural science, 4(10), 48.

Masipa T. (2017). The impact of climate change on food security in South Africa: Current realities and challenges ahead. Jàmbá: Journal of Disaster Risk Studies, 9(1), 1–7.

NASA (2016). NASA Study: Rising Carbon Dioxide Levels Will Help and Hurt Crops. NASA.

Nastis S.A., Michailidis A. & Fotios C. (2012). Climate change and agricultural productivity. African Journal of Agricultural Research, 7(35), 4885–4893.

Ngongeh L., Idika K., & Agbede R. (2014). Climate change/global warming and its impacts on parasitology/Entomology. The Open Parasitology Journal. 5 (1), 1–11.

Obama B. (2009). Remarks by the President to the Ghanaian Parliament. Available online: https://obamawhitehouse.archives.gov/the-press-office/remarks-president-ghanaian-parliament (accessed on 6 April 2025).

Ogbuabor J.E., Emeka E.T., Orji A. (2025) Effect of Resource Rent on Infrastructural Development in Africa: Moderating Role of Governance Institutions. Politická ekonomie, 73(1), 31–57. https://doi.org/10.18267/j.polek.1450

Ogbuabor J.E., Emeka E.T., Orji A., Onuigbo F.N. (2024a) Effects of Trade Openness and International Financial Inflows on Africa's Productive Capacity: A Study of the Moderating Role of Governance Institutions. Politická ekonomie, 72(3), 501–564. https://doi.org/10.18267/j.polek.1423

Ogbuabor J.E., Emeka E.T., Orji A. & Onuigbo F.N. (2023). The effects of international financial inflows on economic complexity in Africa: does institutional quality play a moderation role? Journal of Economic Policy Reform, 26(4), 348–369. https://doi.org/10.1080/17487870.2023.2220862

Ogbuabor J.E., Orji A., Manasseh C.O. and Anthony-Orji O.I. (2020). Climate change and agricultural output in the ECOWAS region. International Journal of Sustainable Economy, 12(4), 403–414. https://doi.org/10.1504/IJSE.2020.10031431

Ogbuabor J.E. & Egwuchukwu E.I. (2017). The impacts of climate change on the Nigerian economy. International Journal of Energy Economics and Policy, 7(2), 217–223.

Ogbuabor J., Orji A., Anthony-Orji O., & Onuigbo F.N. (2020). Institutional Quality and Economic Performance in Nigeria: A New Evidence. International Journal Of Economics and Statistics, 8, 38–49. https://doi.org/10.46300/9103.2020.8.7

Okolo C.V., Susaeta A., Orji A., Ogbuabor J.E. (2024b). Environmental health performance and the nexus between terrorism and the economics of technological innovation. Journal of Environmental Studies and Sciences. https://doi.org/10.1007/s13412-024-00992-4

Oloruntuyi A.O. & Adigun A.O. (2017). Economic Analysis of the effects of climate change on agricultural productivity in Nigeria. Journal of Research in National Development, 15(1).

Onyeneke R.U., Ejike R.D., Osuji E.E., & Chidiebere-Mark N.M. (2022). Does climate change affect crops differently? New evidence from Nigeria. Environment, Development and Sustainability, 26, 393–419. https://doi.org/10.1007/s10668-022-02714-8

Sambo U., & Sule B. (2024). Impact of Climate Change on Food Security in Northern Nigeria. Green and Low-Carbon Economy, 2(1), 49–61. https://doi.org/10.47852/bonviewGLCE3202560

Sekumade A.B. (2009). The effects of petroleum dependency on agricultural trade in Nigeria: An error correction modelling (ECM) approach. Scientific Research and Essay, 4(11), 1385–1391.

Solomon E. & Edet O.G. (2018). Determinants of climate change adaptation strategies among farm households in Delta State, Nigeria. Current Investigations in Agriculture and Current Research, 5(3), 61–68.

Subramaniam Y., Masron T.A., & Subramaniam T. (2020). Institutional quality and food security. The Singapore Economic Review, 1–29.

World Bank. (2014). Turn down the heat: confronting the new climate normal. The World Bank.

Zwane E.M. (2019). Impact of climate change on primary agriculture, water sources and food security in Western Cape, South Africa. Jàmbá: Journal of Disaster Risk Studies, 11(1), 1–7.