CLIMATE CHANGE AND FOOD PRODUCTION: INVESTIGATING AGRICULTURE-INDUCED GREENHOUSE GAS EMISSIONS IN NIGERIA

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ABSTRACT

This research investigated the effect of agriculture-induced greenhouse gas emissions on food production in Nigeria from 1981 to 2022. The Auto-regressive Distributed Lag (ARDL) methodology is employed. Findings revealed that agriculture-induced greenhouse gas emission negatively affected food production during the period of the study, however, its effect is found to be insignificant. The rise in the magnitude of agriculture-induced greenhouse gas emission from 7% to 20% in the short-term and long-term respectively is an indication that agriculture-induced greenhouse gas emission portends great danger towards the achievement of adequate food production in Nigeria. The result of the findings also implies that the status of the agricultural sector as the highest emitter of greenhouse gas emissions in Nigeria does not necessarily transmit to making its negative impact on food production significant. Thus, this research recommends the training of farmers through workshops and agricultural extension services to practice climate-smart agriculture to ensure that greenhouse gas emission from agriculture is minimized and to reverse this negative trend possibly. The elimination of bush burning and deforestation, the use of organic manure as against synthetic fertilizers, the practice of irrigation farming, and modern livestock practices (ranching) should be encouraged among farmers by the government both at the Federal, State, and Local government levels through the various established agricultural ministries and agencies in the country.
Keywords: Auto-regressive Distributed Lag, Food Production, Greenhouse Gas; and Nigeria.
JEL Classification: B41, Q11, Q54, N57.

1. INTRODUCTION

FAO (2017) suggests that despite global advancements in living standards, food insecurity remains a major challenge. The rising global population has intensified food demand, further exacerbated by climate change and insecurity (Todaro & Smith, 2015; Ovikuomagbe & Olusola, 2023). In 2019 and 2023, approximately 690 million and 733 million people, respectively, suffered from hunger worldwide. Africa has been particularly affected (Miron, Linares & Diaz, 2023); more than 270 million people of the 750 million people suffer from some form of malnutrition associated with inadequate food supplies (Todaro & Smith, 2015). Malnutrition in Africa has worsened, increasing from 17.6% in 2014 to 19.1% in 2019. In Nigeria, food insecurity has escalated, with the country ranking 86th out of 107 nations in the Global Food Security Index in 2013, dropping to 94th out of 113 countries by 2019; and further reaching its lowest ranking in 2022 by becoming 107th out of 113 nations (FAO, 2019;

Abbah, Doki & Andohol, 2024). Comparatively, Ethiopia, Niger, and Cameroon have demonstrated better food sufficiency than Nigeria (Ayinde, Johnson, Olujimi, Dasgupta & Akerele, 2022). Agricultural output growth has been at its lowest rate in six decades. While global food production grew at 2.79 percent annually in the 1960s, it declined to 1.93 percent between 2011 and 2020. Developing countries have also experienced a drop in agricultural output growth, falling from 3.91 percent in the 1990s to 2.19 percent in the 2010s. In Nigeria, the food production index fluctuated between 1981 and 2022, with periods of increases and declines. Food production grew by 4.2 percent between 2018 and 2019 but fell to 1.12 percent between 2019 and 2020 and increased marginally to 1.93 percent by 2021 (World Bank, 2023). Previous growth was driven by improved productivity, increased inputs, irrigation expansion, and land use, whereas recent declines are largely attributed to climate change (Afzali, GharehBeygi, & Dero 2020; Jelliffe, Fuglie & Morgan, 2022).

Climate change evidenced by rising temperatures, droughts, and rainfall variability, including floods; contributes to poor plant and animal growth, ultimately leading to reduced food production (FAO, 2017; Okafor, Ejiogu, Akakuru, & Okonkwo, 2024; Nkhonjera & Megersa, 2017; & Oduntan, Obisesan & Ayo-Bello, 2022). These factors are also responsible for increased pests and diseases that affect plant and animal productivity (Machalaba, Romanelli, Stoett, Baum, Bouley, Daszak, & Karesh, 2015). Furthermore, decreased forage for animals due to climate change especially in the northern part of Nigeria is the recipe for the unending conflict between herders and farmers that has dislocated the food production chain, which is evidenced in food shortages across the country (Andohol, Doki, & Ojiya, 2020; Abbah, Nungul, Busari & Manu, 2023).

The Sustainable Development Goal, zero hunger (SDG 2), is the global response to the problem of hunger and malnutrition. By 2030, this goal seeks to eradicate hunger, attain food security, enhance nutrition, and advance sustainable agriculture (FAO, 2017). However, there seems to be a problem associated with the achievement of this goal that has not been given adequate attention by scholars across the globe particularly in Nigeria. According to FAO (2017), food production will increase astronomically by 2030, and greenhouse gas emission is projected to be positively associated with this food increase. Furthermore, the classification of the agricultural sector in Nigeria by the Department of Climate Change (2021) as the highest emitter of greenhouse gas emissions makes this situation complex for Nigeria as regards striking a balance between adequate food production and environmental sustainability. How will appropriate policy measures be taken when the effect of agriculture-induced greenhouse gas emission is not empirically investigated? Investigating the influence of climate change is important for the growth of the agricultural sector in Nigeria (Agu, Obodoechi, & Ugwu, 2021).

From the foregoing, therefore, this research seeks to investigate the effect of agriculture-induced greenhouse gas emissions on total food production in Nigeria; and to ascertain the statistical significance of agriculture-induced greenhouse gas emissions on total food production in Nigeria to enable appropriate policy formulation. This study is structured under the following headings: introduction, literature review; methodology and data; results and discussions of findings; conclusions and recommendations; and references.

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Food Production

The Organization for Economic Cooperation and Development (OECD, 2024) sees food production as produce from the agricultural sector which comprises output for own consumption, output for further processing, changes in stocks, output sold, and output for livestock consumption. Food production refers to the output produced from the agricultural sector as a result of the combination of factors of production (Anugwom, 2024). Furthermore, FAO (2019) opined that food production involves the combination of capital, land, labor, and technology to grow crops or raise livestock to meet demand.

Food production in this research is conceptualized as the quantity of crops, livestock, fisheries, and forest resources produced from the agricultural sector in Nigeria. The real Gross Domestic Product of agriculture is used to represent food production in this research.

2.1.2 Climate Change

Climate change is opined to be substantial and measurable changes in weather conditions of a place usually over decades (IPCC, 2014). Climate change is seen as changes in nature that result in irregular rainfall patterns, fluctuation in temperature, relative humidity, and other elements of weather (Todaro and Smith, 2015). Furthermore, Ojuederie and Ogunsola (2017) see climate change as the alteration of weather conditions over a long period resulting in changes in the pattern of rainfall, temperature, flooding, desertification, land degradation, and erosion.

Climate change in this research is defined as the combination of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) released into the atmosphere during the process of food production in Nigeria. The combination of these gases in a single unit called carbon dioxide equivalent (CO_2e) is used in this research.

2.2 THEORETICAL REVIEW

2.2.1 The Environmental Kuznets Curve (EKC) Theory

The Environmental Kuznets Curve (EKC) theory, based on Simon Kuznets' 1955 hypothesis, originally described an inverse U-shaped relationship between income inequality and per capita income. It suggests that inequality worsens in the early developmental stages but declines after reaching a certain income level. Grossman and Krueger (1991) extended this concept to environmental quality, proposing that economic growth initially leads to increased pollution, but after a certain income threshold, further growth results in environmental improvement. The EKC theory is related to this research because increased economic growth in the form of increased food production is projected to be accompanied by increased greenhouse gas emissions from the agricultural sector. Sustainable and climate-smart food production practices are expected to improve environmental quality in Nigeria.

2.2.2 The Frustration-Aggression Theory

The frustration-aggression theory, propounded by Dollard, Doob, Miller, Mowrer, and Sears (1939), suggests that frustration leads to aggression, which may be displaced onto weaker targets if the aggression cannot be confronted. Climate change in the forms of drought, desertification, water shortages, rising temperatures; poverty; and poor governance; frustrates farmers, fishermen, herders, and even the unemployed from earning a living. This situation is more prevalent in less developed countries where people are generally poor and unable to mitigate the consequences of climate change, poverty, poor leadership, and other life challenges. These frustrations are evident in illegal activities like terrorism, banditry, insurgency, communal clashes, armed robberies, and herders-farmers conflict, among others. These frustrations often take a toll on the government's expenditure, leading to the diversion of funds meant for economic growth and development of the nation.

2.2.3 The Traditional Neoclassical Growth Theory

The Neoclassical Growth Theory, also known as the Solow-Swan model, was developed by Solow and Swan in 1957 as an alternative to the Harrod-Domar model. It removed the assumption of fixed production proportions and linked economic output to labor and capital as interchangeable inputs. A key departure from the Harrod-Domar model was the introduction of technology as a crucial factor influencing long-term growth. Unlike its predecessor, the Solow-Swan model assumes constant returns to scale but acknowledges diminishing returns to labor and capital individually. It also emphasizes that capital accumulation alone cannot sustain long-term economic growth. Instead, growth is driven by labor, capital, and technological progress, with technology playing a particularly vital role. In this model, technological advancement is considered an external factor that ensures sustained economic expansion. The production function is mathematically represented as $Y = K^{\alpha} (AL)^{1-\alpha}$ where Y is gross domestic product, K is the stock of capital (which may include human capital as well as physical capital), L is labour, and A represents technology, which grows at an exogenous rate. Overall, the Solow-Swan model remains a fundamental framework for understanding economic growth.

2.3 EMPIRICAL REVIEW

2.3.1 Review of the Effect of Climate Change on Food Production

Ikyase and Iloh (2014) used the survey approach to investigate how Nigerian food production is affected by climate change. Findings revealed that Nigeria's economy was negatively affected by climate variability, with the agriculture sector suffering the most. During the study period, it was also discovered that the agriculture sector contributed to greenhouse gas emissions. Climate change is represented by temperature and precipitation, and food security is represented by agricultural GDP.

Using survey methodology, Okoli and Ifeakor (2014) examined the nexus between food production and climate change in Nigeria, taking coping strategies into account. The research findings revealed that agricultural output (agricultural GDP) is negatively affected by climate change (carbon dioxide emissions). Coping measures for the negative impact of climate change have been discovered, including irrigation and watershed management, better and drought-resistant agricultural types, and effective reliance on and use of climate change information.

Osuafor and Nnomrom (2014) investigated the effect of climate variability on food production using a survey approach in Nigeria. Among other things, the study promoted the adoption of better and disease-resistant agricultural seedlings or breeds of animals, and the reduction of deforestation. According to the findings, one of the main factors influencing Nigeria's food security is food output, or the food production index, which is negatively impacted by climate change (carbon dioxide emissions).

In Nigeria, from 1975 to 2010; Idumah, Mangodo, Ighodaro, and Owombo (2016) used the Vector Error Correction methodology to study food production and climate change. Findings revealed that temperature, relative humidity, and rainfall all had an inverse and substantial effect on agricultural production (measured in millions of tons). The study promoted raising farmers' awareness of the influence of climate change and ensuring they receive sufficient training on mitigation strategies and techniques to lessen the inverse effect of climate change on food production.

The research conducted in Nigeria by Gbenga, Opaluwa, Olabode, and Ayodele (2020) investigated how climate change affected crop and livestock production from 1970 to 2016. They used Co-integration and Fully Modified Least Square regression, with temperature, rainfall, and carbon dioxide emissions representing climate change and crop and livestock production as the regressand. The study's findings showed that climate change, as represented by carbon dioxide emissions, had an inverse impact on crop and livestock output in Nigeria during the study period and that crop production was the subsector most significantly impacted by climate change.

Obindah and Chinua (2020) employed the autoregressive distributed lag (ARDL) methodology to investigate how climate changes affected Nigerian agricultural output between 1981 and 2017. The study's conclusions indicate that, although rainfall had a direct and significant impact on livestock output (measured by the livestock production index), temperature and carbon dioxide emissions had an inverse and substantial impact on livestock output (measured by the livestock production index) in Nigeria during the study period.

Sibanda and Ndlela (2020) examined the connection between South Africa's industrial output, agricultural GDP, and carbon dioxide emissions from 1960 to 2017 using the Auto-regressive Distributed Lag approach (ARDL). The research's conclusions showed that industrial output and carbon emissions have an impact on agricultural output or agricultural GDP. While industrial performance boosts agricultural productivity in the study area, carbon emissions decrease agricultural output (agricultural GDP) and, consequently, food security.

With a simulation period from 2010 to 2030, Zerayehu, Dawit, and Tsegaye (2020) examined carbon dioxide (CO_2) emissions, agricultural production, and welfare in Ethiopia using the recursive dynamic computable general equilibrium methodology. Findings showed that carbon dioxide (CO_2) emissions had an inverse effect on household well-being and agricultural output (agricultural GDP).

2.3.2 Gap in Literature

The uniqueness of this study stems from the reality that previous research on the impact of climate change on food production in Nigeria has primarily focused on carbon dioxide (CO_2) because of its prevalence in the atmosphere. However, gases like methane (CH_4) and nitrous oxide (N_2O), which possess higher global warming potentials (GWPs) and cause greater harm to the ozone layer, have been largely overlooked. Furthermore, the threat to food production posed by the agricultural sector, the largest emitter of greenhouse gases, has often been overlooked by researchers. This study addresses climate change by analyzing agriculture-induced carbon dioxide equivalent (CO_2e), which encompasses the combined effect of major greenhouse gases (carbon dioxide, methane, and nitrous oxide) from Nigeria's agricultural sector.

3. METHODOLOGY AND DATA

The nexus between agriculture-induced greenhouse gas emission and food production in Nigeria is investigated using the Auto-Regressive Distributed Lag (ARDL) methodology. The Augmented Dickey-Fuller (ADF) unit root test is used for the stability of research data. The F-bounds test for co-integration is employed to check for long-term nexus. Finally, the Ramsey RESET test, the Breusch-Godfrey Serial Correlation LM test, and the Breusch-Pagan-Godfrey Heteroskedasticity test are employed to ascertain the forecasting capacity of the estimates.

The data for this research include: food production (the dependent variable) represented by agricultural real GDP, while the independent variables are: climate change represented by agriculture-induced carbon dioxide equivalent (the aggregation of carbon dioxide, methane, and nitrous oxide emission from agriculture); annual rainfall, annual mean temperature, agricultural credit guarantee scheme fund, commercial bank loans and advances, employment in agriculture, arable land, and insecurity represented by government military expenditure. These data were sourced from the World Bank (WB), and the Central Bank of Nigeria (CBN).

3.1 Theoretical Framework

The research is built on the Solow-Swan (1957) theory which states that economic growth relies on technology, capital, and labour. The Solow-Swan theory is an extension of the Cobb-Douglas production function formulated by Cobb and Douglas in 1928. This theory presents a perfect model for expressing the nexus between climate change and food production in Nigeria. Economic growth which encompasses food production is affected by advancement in technology (industrialization), and capital accumulation in the form of machinery used for the production of goods and services in an economy. The growing industrial sector in Nigeria poses a great threat to food production as a substantial amount of greenhouse gases are emitted from this sector which impacts food production.

The Solow-Swan model is explicitly expressed thus:

$$Y = K^{\beta}(AL)^{\alpha} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The linearized form of the Solow-Swan model is expressed thus:

$$lnY = lnA + \beta\, lnK + \alpha - 1 lnL \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

3.2 Model Specification

The empirical models of Idumah, Mangodo, Ighodaro, and Owombo (2016); Obinda and Chinua (2020); and Ilesanmi and Odefadehan (2022) presented in equations (3), (4), and (5) respectively; and the theoretical model were modified to arrive at equation (6).

$$AGRICOUTPUT = f(TEMP, RAINFALL, RELHUM)\ldots\ldots\ldots\ldots(3)$$

Where: AGRICOUTPUT = agriculture output, TEMP = temperature, RAINFALL = rainfall, and RELHUM = relative humidity.

$$Y = f(MAR, MAT, CO_2E, AGE, AL, CMA)\ldots\ldots\ldots\ldots(4)$$

Where: Y = crop output, MAR = rainfall, MAT = temperature, CO_2E = carbon dioxide emissions, AGE = government expenditure on agriculture, AL = arable land, and CMA = crop manure.

$$AGDP = f(POVR, UNEMP, CIR, GEXIS)\ldots\ldots\ldots\ldots(5)$$

Where: AGDP = agricultural gross domestic product, POVR = poverty, UNEMP = unemployment, CIR = crime, and GEXIS = government expenditure on internal security.

The nexus between agriculture-induced greenhouse gas emissions and total food production in Nigeria is presented in equation (6) thus:

$$FP = f(AC0_2e, ACGSF, CBLA, RAF, TEM, EA, AL, INS)\ldots(6)$$

The stochastic form of the research model is presented thus:

$$lFP = \alpha_0 + \alpha_1 lAC0_2e + \alpha_2 lACGSF + \alpha_3 lCBLA + \alpha_4 lRAF + \alpha_5 TEM + \alpha_6 EA + \alpha_7 AL + \alpha_8 INS + \ell \ldots\ldots\ldots\ldots(7)$$

Where: FP = food production, ACO_2e = agriculture-induced carbon dioxide equivalent, ACGSF is agricultural credit guarantee scheme fund, CBLA = commercial bank loans and advances, RAF = annual rainfall, TEM = annual mean temperature, EA = employment in agriculture, AL = arable land, insecurity (INS); α_0 - α_8 = Structural parameters estimated, and ℓ = the disturbance or random term.

Equation (7) is transformed into the ARDL form and presented thus:

$$\Delta lFP_t = \alpha_0 + \sum_{i=1} 0\alpha_{1i}\Delta lFP_{t-1} + \sum_{i=1} 0\alpha_{2i}\Delta lACO_2e_{t-1} + \sum_{i=1} 0\alpha_{3i}\Delta lACGSF_{t-1} + \sum_{i=1} 0\alpha_{4i}\Delta lCBLA + \sum_{i=1} 0\alpha_{5i}\Delta lRAF_{t-1} + \sum_{i=1} 0\alpha_{6i}\Delta TEM + \sum_{i=1} 0\alpha_{7i}\Delta EA_{t-1} + \sum_{i=1} 0\alpha_{8i}\Delta AL_{t-1} + \sum_{i=1} 0\alpha_{9i}\Delta INS_{t-1} + \beta_1 lFP_{t-1} + \beta_2 lACO_2e_{t-1} + \beta_3 lACGSF_{t-1} + \beta_4 lCBLA_{t-1} + \beta_5 lRAF_{t-1} + \beta_6 TEM + \beta_7 EA_{t-1} + \beta_8 AL_{t-1} + \beta_9 INS + \vartheta 1ECT_{t-1} + \lambda_{1t} \quad \text{.......(8)}$$

Where: ϑ_1 = adjustment speed, and ECT_{t-1} = error correction term.
A priori expectation: ACO2e, INS, and POV are expected to be < 0. While; AL, EA, CBLA, ACGSF, RAF, and TEM are expected to be > 0.

4. RESULTS AND DISCUSSIONS ON FINDINGS

Table 1: Descriptive statistics

	FP (₦ B)	AC02E (Kt)	ACGSF (₦ M)	CBLA (₦ B)	RAF (MM)
Mean	8725.956	51.03141	54093.56	231.1818	1160.578
Maximum	19091.07	81.00773	246082.5	1812.470	1296.780
Minimum	2303.505	31.70354	361.4504	0.590600	888.0600
Skewness	0.460303	0.594175	1.476554	2.442378	-0.777393
Kurtosis	1.646232	2.078118	4.080895	8.814442	3.892508
Jarque-Bera	4.690353	3.958573	17.30606	100.9200	5.624381
Probability	0.095830	0.138168	0.000175	0.000000	0.060073
Sum	366490.2	2143.319	2271930	9709.637	48744.28
Observations	42	42	42	42	42

Source: Extract from E-views 10 Output (2025).

	TEM (^{0}C)	EA (%)	AL (%)	INS (%)
Mean	33.20571	33.94250	36.38504	2.605394
Maximum	33.83000	52.35656	40.48443	7.323454
Minimum	32.49000	37.98524	29.23131	1.470257
Skewness	-0.305967	-1.023268	-0.672892	0.000182
Kurtosis	2.651739	2.340378	1.732493	3.021929
Jarque-Bera	0.867559	8.090962	5.980987	0.000842
Probability	0.648055	0.017501	0.050263	0.999579
Sum	1394.640	1425.585	1528.172	109.4265
Observations	42	42	42	42

Source: Extract from E-views 10 Output (2025).

Table 1 presents the descriptive statistics. Food production (FP), agriculture-induced greenhouse gas emission ($AC0_2E$), agriculture credit guarantee scheme fund (ACGSF), commercial loans and advances in agriculture (CBLA), rainfall (RAF), temperature (TEM), employment in agriculture (EA), arable land (AL), and insecurity (INS) averaged ₦8725.96 billion, 51.03 kilo tonnes, ₦54093.56 million, ₦231.18 billion, 1160.58 millimeter, 33.21 degree Celsius, 33.94 percent, 36.39 percent, and 2.61 percent respectively. During the period of the study, the maximum values of food production (FP), agriculture-induced greenhouse gas emission ($AC0_2E$), agriculture credit guarantee scheme fund (ACGSF), commercial loans and advances in agriculture (CBLA), rainfall (RAF), temperature (TEM), employment in agriculture (EA), arable land (AL), and insecurity (INS) were ₦ 19091.07 billion, 81.01 kilo tonnes, ₦246082.5 million, ₦1812.47 billion, 1296.78 millimeters, 33.83 percent, 52.36 percent, 40.48 percent, and 7.32 percent respectively. Their corresponding respective minimum values stood at ₦2303.51 billion, 31.70 kilo tonnes, ₦361.45 million, ₦0.59 billion, 888.06 millimeters, 32.49 degrees Celsius, 37.99 percent, 29.23 percent, and 1.47 percent.

Finally, the Jarque-Bera test values revealed that the variables of interest are not normally distributed; hence the Augmented Dickey-Fuller (ADF) unit root test is employed for the verification of the stability levels.

Table 2: The Augmented Dickey-Fuller (ADF) unit root test result

Variables	ADF @ Level	Prob.	ADF @ 1st Diff.	1% Critical Value	5% Critical Value	10% Critical Value	Prob.	Order of Integration
LFP	-0.38	0.90	-6.06*	-3.61	-2.94	-2.61	0.0000	I(1)
LACO$_2$e	0.39	0.98	-8.12	-3.61	-2.94	-2.61	0.0000	I(1)
LACGSF	-1.91	0.29	-6.70***	-3.61	-2.94	-2.61	0.0000	I(1)
LCBLA	-0.80	0.81	-7.26**	-3.61	-2.94	-2.61	0.0000	I(1)
LRAF	-4.86*	0.00	-	-3.60	-2.94	-2.61	-	I(0)
TEM	-1.49	0.53	-9.59***	-3.61	-2.94	-2.61	0.0000	I(1)
EA	-1.92	0.32	-6.25*	-3.61	-2.94	-2.61	0.0000	I(1)
AL	-1.75	0.40	-5.42*	-3.61	-2.94	-2.61	0.0001	I(1)
INS	-2.27	0.19	-7.41***	-3.61	-2.94	-2.61	0.0000	I(1)

Source: Extract from E-views 10 Output (2025).
Note: the asterisks show the levels at which each variable is stationary.

The Augmented Dickey-Fuller (ADF) unit root test is presented in Table 2. The result revealed that all the variables of interest are integrated into order I(1) except rainfall (RAF) which is integrated into order I(0). The optimal lag order selection criterion is presented in Table 3.

Table 3: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-106.2544	NA	2.57e-09	5.762722	6.142720	5.900117
1	180.4105	429.9973*	9.70e-14*	-4.520523	-0.720544*	-3.146571*
2	272.4670	96.65935	1.07e-13	-5.073349*	2.146611	-2.462840

Source: Extract from E-views 10 Output (2025).

Table 3 presents the result for the optimal lag order selection criteria for the model specified for this research. The optimal lag length for the examination of the nexus of the variables of this research is AIC lag 2.

Table 4: ARDL F-Bounds test, Short-run and Long-run estimates

Model 1: Agriculture-induced greenhouse gas emission and total food production

Panel A: ARDL F-Bounds Test				
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	10.41427	10%	1.85	2.85
K	8	5%	2.11	3.15
		1%	2.62	3.77
Panel B: Short-run estimates				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-2.071180	1.917158	-1.080339	0.2943
LAC02E$_{t-1}$	-0.072564	0.297753	-0.243706	0.8102
LACGSF$_{t-1}$	-0.044270	0.009720	-4.554654	0.0002
LCBLA $_{t-1}$	0.150499	0.047868	3.144050	0.0056
LRAF$_{t-1}$	0.151800	0.236861	0.640884	0.5297
TEM	0.107198	0.047853	2.240171	0.0379
EA$_{t-1}$	0.001002	0.000531	1.888575	0.0752

AL_{t-1}	-0.012145	0.007800	-1.557037	0.1369
INS_{t-1}	-0.023646	0.010819	-2.185654	0.0423
ECT_{t-1}	-0.360606	0.028852	-12.49856	0.0000
Panel C: Long-run estimates				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LAC02E	-0.201228	0.856060	-0.235063	0.8168
LACGSF	-0.122765	0.036783	-3.337569	0.0037
LCBLA	0.417349	0.146660	2.845683	0.0107
LRAF	0.420958	0.625756	0.672719	0.5097
TEM	0.297272	0.123263	2.411681	0.0268
EA	0.002779	0.001296	2.143982	0.0459
AL	-0.033678	0.022112	-1.523055	0.1451
INS	-0.065572	0.021633	-3.031184	0.0072

Source: Extract from E-views 10 Output (2025).

Table 4 presents ARDL estimates in panels A, B, and C. In panel A, the F-statistic value of 10.41 reveals the long-run nexus between the data series of the model. In the short-term in panel B and the long-term in panel C; agriculture-induced greenhouse gas emissions negatively affected food production. However, its impact is not substantial. This result agrees with the apriori expectation of the research in terms of the sign.

Furthermore, the result complies with research done in Nigeria by Okoli and Ifeakor (2014), and Osuafor and Nnomrom (2014). The findings also concur with the research done in Ethiopia by Zerayehu, Dawit, and Tsegaye (2020), work done in South Africa by Sibanda and Ndlela (2020); research carried out in China by Zhang, Zhang, and Chen (2017), and a study done in western United States by Liu and Wimberly (2016). This result contradicts the findings of the FAO (2017) and the Intergovernmental Panel on Climate Change (2014) in terms of the statistical significance of the research hypothesis.

The negative but insignificant effect of agriculture-induced greenhouse gas emission on total food production in Nigeria is an indication that the agricultural sector contributes to the problem of climate change, and reduces food production in Nigeria as noted by Ikyase and Iloh (2014), but its effect is yet to be significant. The statistical insignificance of the climate change variable is likely unconnected with the lack of industrialization of agriculture in Nigeria; terrorism and the unending herders-farmers conflict that has truncated farming activities across the country, in addition to the low rate of agricultural investment. However, a cursory look at the magnitude of the climate change variable from the short-term into the long-term will reveal that urgent attention needs to be paid to the quest for increased food production that is likely to be accompanied by the projected increase in greenhouse gas emission across the globe and especially in less developed nations like Nigeria. The destruction of forests for farmlands, bush burning, and the application of synthetic fertilizers are likely factors that would have caused this negative transmission to food production. The error correction term is within acceptable limits and statistically significant.

Table 5: Diagnostics Test

Diagnostic and Post-Estimation Results				
Adj. R^2	**F-statistics**	**Ramsey RESET**	**Breusch-Godfrey Serial Correlation LM Test**	**Heteroskedasticity Test: Breusch-Pagan-Godfrey**
0.797099	10.41427	0.750396	0.627861	1.423031
		(0.4633)	(0.5464)	(0.2267)

Source: Extract from E-views 10 Output (2025).

Table 5 revealed the result of the diagnostic tests of the model of the study. The adjusted coefficient of determination (Adj. R^2) indicates that 78 percent of the variation in food production is caused by the variables of interest employed in the model of this study. The remaining 22 percent variation in the dependent variable is a result of the changes caused by other factors not included in the model of this study. The Ramsey Rest value indicates that the model of this research is correctly specified. Furthermore, the serial correlation and heteroskedasticity test values revealed the absence of autocorrelation and the presence of constant variance among the random terms of the variables of interest. The CUSUM and the CUSUM square stability results are shown in Figures 1 and 2.

Fig 1: CUSUM

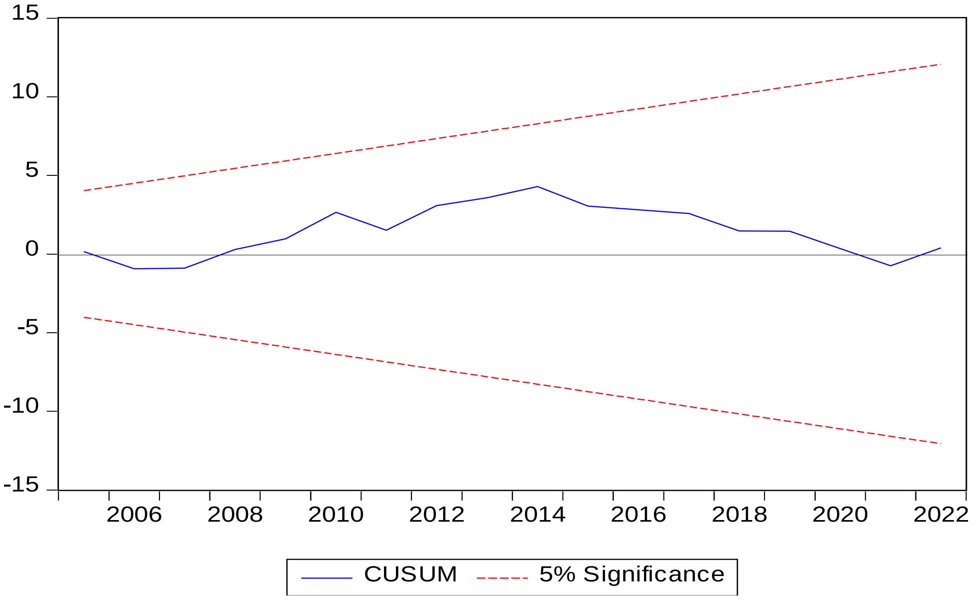
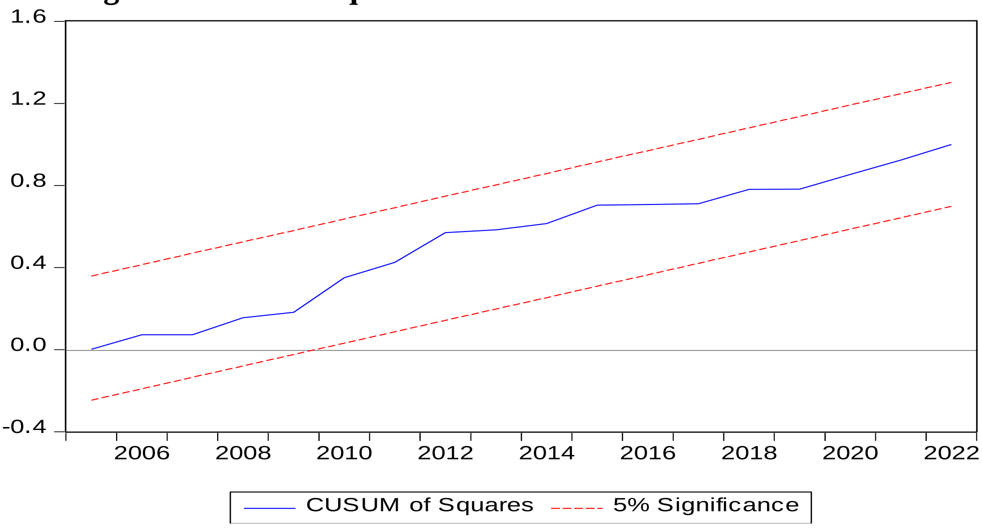


Fig 2: CUSUM of Square



Source: Extract from E-views 10 Output (2025).

Fig 1 and Fig 2 present the results of the CUSUM and the CUSUM square stability test respectively. These diagrams revealed that the parameters of the model are stable throughout the study. As such, its estimates can be relied upon for forecasting and policy formulation.

5. CONCLUSIONS AND RECOMMENDATIONS

This study concludes that agriculture-induced greenhouse gas emission has a negative impact on total food production in Nigeria. However, its effect is not statistically significant. This finding is intriguing, as the empirical results suggest that emissions from the agricultural sector have the potential to become a major challenge for food production. Nonetheless, the claim by the Department of Climate Change that agriculture is the largest contributor to global warming in the country does not necessarily imply that its greenhouse gas emissions have a significant impact on food production.

The training of farmers through workshops and agricultural extension programs by government trained agricultural extension agents in Nigeria to promote climate-smart agriculture is recommended to reverse the negative trend. The government, at federal, state, and local levels, through their various ministries of agriculture; and Non-Governmental Organizations (in the area of climate-smart agriculture and sustainable development) should provide funds to farmers and encourage sustainable agricultural practices involving the elimination of bush burning and deforestation, the use of organic manure instead of synthetic fertilizers, implementing irrigation farming, and adopting modern livestock management techniques like ranching.

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