IMPACT OF CLIMATE CHANGE ON FOOD SECURITY IN NIGERIA: IS TERROR ATTACK A MATTER OF CONCERN?

NUHU MUSA
Department of Economics, Kogi State University, Anyigba, Kogi State, Nigeria
**Corresponding author: musanuhuadams@gmail.com*
Phone Number: +2347060526595

ALI MAJI
Department of Economics, Kogi State College of Education, Ankpa, Kogi State, Nigeria
majiali1964@gmail.com, +2347058557161

IBRAHIM YUSUF AJOGWU
Department of Economics, Kogi State College of Education, Ankpa, Kogi State, Nigeria
ibrahimyusufakor@gmail.com, +2348039137245

ABSTRACT
Motivated by extreme weather events and incessant terrorist attacks in many parts of Nigeria with attendant consequences on agricultural output and food security challenges, this study was undertaken with a view to addressing the problem. Arising from the above, the objective of this study is to examine the impact of climate change and terrorism on food security in Nigeria using Autoregressive Distributed Lag (ARDL) method on time series data from 1990 to 2024. Food production index is regressed on temperature anomaly, carbon dioxide (CO_2) emission and terrorism index. To improve the robustness of our model result, we incorporate other control variables such as population growth rate and GDP per capita. The data for this study is sourced from World Bank climate change knowledge portal and Central Bank of Nigeria Statistical Bulletin online database. Findings indicate that temperature anomaly and CO_2 emissions negatively influenced food security, highlighting the urgent need for climate mitigation action. Similarly, terrorism exerts a strong negative impact on food security, stressing the need to urgently initiate policies targeted at combating the menace of terrorism in Nigeria and other developing countries. The finding from this study is imperative for government and policy analysts to adopt climate mitigation strategies aimed at reducing carbon emission in order to ensure adequate and sustainable food supply for the country's growing population.
Keywords: Climate change; food production index; terrorism index; greenhouse gas emission; temperature anomaly
JEL Codes: Q00, Q18, Q54

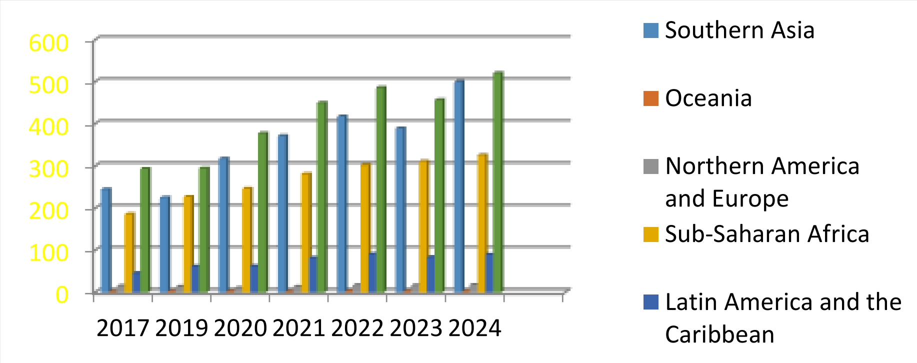
1. INTRODUCTION
In the past few decades, the increasing impact of climate change on food security has attracted global discourse. Many scholars (see, Masipa, 2017; Affoh *et al.* 2022; Gobezie & Boka, 2023) posit that rising temperature, environmental degradation, drought and extreme flooding pose serious challenges to food security in sub-Saharan Africa. Ensuring food security is fundamental for the overall attainment of sustainable development goals (SDGs) in Africa. This is premised on the fact that nourished and healthy people are the primary goals of sustainable development. Many scholars argue that climate change and terrorism are the key drivers to food insecurity globally. Climate change leads to increase in greenhouse gas emission, potentially leading to increase in the prevalence of malnutrition rate (Affoh *et al.*, 2022).

Since 1990s, quite a number of terrorist groups have emerged globally which include Al-Shabaab operating in Somalia and Kenya, the Taliban in Afghanistan and Pakistan, Al-Qaeda in Middle east and the Islamic State in West-African Province (ISWAP) and Balochistan Liberation Army (BLA). Islamic State (IS) is one of the deadliest terrorist organizations, causing 1,805 million deaths across 22 countries in 2024 (Global terrorism index, 2025).

Nigeria is among African economies largely vulnerable to climate shocks, and ranks 6th among countries highly affected by terrorism (Elias & Kazeem, 2024). In Nigeria, Farmers-Herders conflict and Boko Haram insurgency have led to displacement of farmers in various communities, leading to food supply shortages and escalation of food prices across the country (Abbah *et al*.,2025). In fact, in 2024, approximately 900 million people worldwide were in severe food insecurity (FAO, 2024). Surprisingly, of the 900 million people the FAO adjudged as being in protracted food crisis globally, 58 percent live in 22 countries and are also affected by violent conflict.

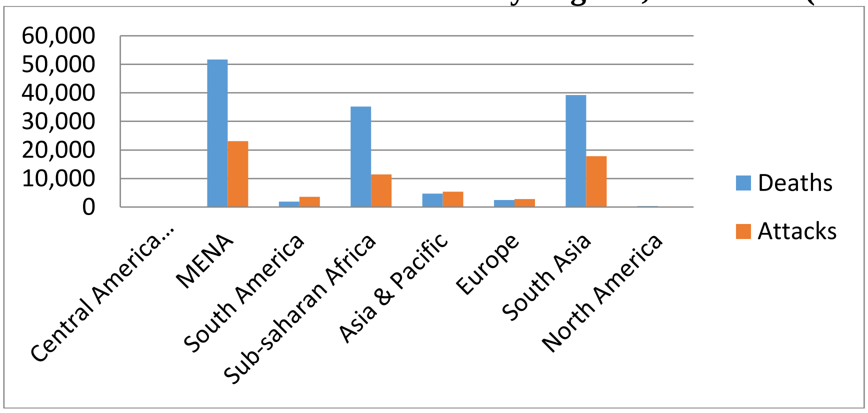
Figure 1 displays trend analysis of food security across some selected regions. From the graph, Asia and sub-Saharan Africa have the highest rates of food insecurity estimated at 456.9 and 310.6 million people, respectively with Southern Asia, 389.2 million and about 1.5 million people in Oceania. Similarly, in Latin America and the Caribbean, roughly about 83.4 million people were affected by severe hunger, whereas, a miniscule of 16.5 million people in Northern America and Europe were affected by food insecurity.

Figure 1: Trend of severe food insecurity in selected regions (million)



Source: Food and Agriculture Organization, 2024 URL:www.fao.org

Figure 2. Number of deaths and attacks by regions, 2007-2024 (Million)



Source: Food and Agriculture Organization, 2024

As shown in Figure 2, between 2007 and 2024, the largest numbers of deaths due to terrorist attacks were recorded in Middle East and North Africa (MENA) .MENA accounted for 51,679 deaths, South Asia recorded 39,246 million, while sub-Saharan Africa recorded 35,256 million deaths during the same period. Asia & Pacific and Europe recorded 4,687 and

2,478 number of deaths while South America, North America, Central America and the Caribbean recorded the least number of deaths at 1,919,285 and 33 million respectively.

There exist plethora of literature on climate change and food security across the world and regions (see, for example, Edame, *et al.* 2011; Gadédjisso-Tossou *et al.*,2016; Masipa, 2017; Haile *et al.*, 2017; Ofuoku & Okompu,2022; Affoh *et al.*,2022; Mutengwa *et al*.,2023; Gobezie, & Boka,2023). However, none of these studies explored the complex interactions between climate change, terrorism and food security in Nigeria. In addition, previous studies (see, for example, see Osuafor &Nnorom, 2014; Imen & Abdelkarim,2023; Wang, *et al.,* 2023), used descriptive statistics, OLS and quantile regressions, potentially leading to misleading and biased policy recommendations. The current study fills the knowledge gap by exploring the nexus between climate change, terrorism and food security in Nigeria, utilizing a linear, ARDL approach which can effectively handle variables with mixed order of integration.

This study makes three significant contributions to the existing frontier of knowledge. First, this paper focuses on the escalating impact of climate change on food security within the Nigerian context. It specifically looks at the mediating role of terrorism on food security in Nigeria which has received little empirical attention. Second, by focusing on country-specific, Nigeria, a country highly vulnerable to climate shocks, the study potentially adds significant contributions to the global discourse. Third, the outcome of our investigation offers valuable insights to government and policy analysts both in Nigeria and other developing countries, to adopt and implement climate mitigation strategies that would make economies more resilience to climate change impacts.

Our primary objective here is to investigate the impact of climate change and terrorism on food security in Nigeria. We hypothesize that terrorism and climate change do not significantly induce food security in Nigeria. To achieve this target, the study utilizes ARDL approach using time series data from 1990 to 2024.Following this introductory section, the remaining paper is structured into literature review, methodology, results and discussion, and finally conclusion and policy recommendations.

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Climate change

Climate change is any change in the climate due to natural variability or human activities (Abbah *et al*. 2025). Climate change leads to increase concentration of carbon dioxide in the atmosphere which ultimately affects the component of food system; accessibility, availability, utilization and stability (Wheeler & von Braun, 2013; Umar *et al*., 2021).

2.1.2 Terrorism

Terrorism as used in this context refers to any activity orchestrated by individual or group of individuals to disrupt peace and tranquility and to achieve defined objectives through the use of force/violence. In Nigeria this act is being perpetrated by Boko Haram insurgency and farmers-herders conflict which affect agricultural activities and disrupt food supply chain. Terrorism is classified into two; domestic and international.

2.1.3 Food security

Food security refers to a situation in a country when all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life (FAO,2024). From the foregoing definition, the concept of food security encompasses four basic requirements which include; availability, stability, accessibility and utilization.

2.2 Theoretical Literature

2.2.1 Sen's Theory of poverty and famine

The theory succinctly argued that the prevalence of food insecurity among household was basically as a result of lack of purchasing power. The theory approaches food security from the perspective of accessibility by vulnerable in the society (Muzerengi *et al.,* 2021)

2.1.2 Neo-classical growth theory

The neo-classical growth theory also called Solow-Swan model posits that economic growth depends efficiency of capital and labour and technological progress. This theory is relevant to this study because .economic growth measured by food production is affected by technology (industrialization). The growing industrial sector poses serious threat to food production through greenhouse gas emission (Abbah, *et al*. 2025).

2.1.3 Environmental Kuznet Curve

The theory argues that there exist an inverted U-shaped correlation between carbon emission and economic growth. The hypothesis posits that the amount of carbon emissions first increases with economic growth, but over time, when the economic growth levels of a country reaches a certain threshold level, growth declines. This situation is referred to as the Kuznets inverted U-shaped hypothesis (Song *et al*., 2013). The theory has relevance to this study because increased economic growth in the form of increased food production is associated with carbon emission. Climate-smart agricultural practices are expected to improve environmental quality and increase food production in Nigeria.

2.3 Empirical Review

Abbah *et al.* (2025) used auto-regressive distributed lag approach (ARDL) to investigate the effect of climate change on food production. Findings revealed that Nigeria's agricultural food production was negatively affected by climate variability. ImandoJemu *et al. (*2024) examined the nexus between food production and climate change in Nigeria using a dynamic computable general equilibrium model. It was discovered that Nigeria's agricultural output was negatively affected by climate change. Elias and Kazeem (2024) explored the impact of climate change on food security using GARCH-MIDAS framework. They found that wars and terrorism rather than climate change was the major determinant of volatility of commodity prices. Yusuf et *al.* (2022) studied food security and agriculture in Nigeria. They discovered lack of adequate financing of agriculture triggered food security in Nigeria. Alehile *et al.* (2022) investigated the effect of climate change on food production from 1990 to 2020 using nonlinear ARDL approach. The findings revealed that agricultural output was negatively affected by climate change. Using Robust OLS model, Agu *et al*. (2021) found that food security was negatively impacted by climate change.

Weldegiagis *et al*. (2023) did a study on the impact of conflict on food insecurity among the household in Tigray, Ethiopia. Their findings showed that armed conflicts had significant negative effect on food security. Parsons and Naghspour (2023) studied the impact of terrorism on food security using a panel data of 106 countries spanning 1988 to 2018. The results showed that internal conflict increases food insecurity in developing countries. Alexandridis *et al*. (2023) further emphasize the negative effects of climate risks on crops, potentially limiting food availability. Yaqoub *et al*.,(2017) used the descriptive analysis to investigate the impact of climate change impacts on food security in Eastern Sudan. The study discovered climate change induces food security. The finding of the study was consistent with submissions by Mutengwa (2023). Masipa (2017) used correlation and descriptive analysis to estimate the impact of climate change in South Africa from 1973 to 2012. The findings revealed a negative and significant relationship between climate change and food security.

2.4 Gaps in Literature

From the foregoing reviewed literature, we discovered that there are basically few studies that examined the complex interactions between climate change, terrorism and food security in Nigeria. Many previous studies concentrated on the impact of climate change on food security, ignoring the mediating role of terrorism (see, for example, Affoh *et al.*, 2022; Mutengwa *et al*., 2023; Gobezie, & Boka, 2023). Therefore, this study uniquely addresses the research gap by exploring the dynamic nexus between climate change, terrorism and food security in Nigeria. Another major gap stems from the methodological point of view; previous studies (see, for example, Osuafor &Nnorom, 2014; Imen & Abdelkarim, 2023; Wang, *et al.*, 2023), relied exclusively on descriptive statistics or traditional ordinary least square (OLS) and quantile regressions, potentially leading to misleading and biased policy recommendations. The current study fills the knowledge gap by utilizing a linear, ARDL model which can effectively handle variables with mixed order of integration. To make our results robust, this study used two climate indicators (temperature anomaly and C02 emission) and incorporates some control variables like population growth rate and per capita GDP and also carries out post-mortem tests, including heteroscedasticity, Ramsey, normality and autocorrelation test.

3. METHODOLOGY AND DATA

3.1 Theoretical Framework

The theoretical framework for this study is anchored on the neoclassical growth model also called Solow-Swan theory. This theory provides a perfect model for expressing the complex dynamic relationship between climate change and food security in Nigeria. Economic growth represented by food production is affected by terrorism, thus justifying the inclusion of terrorism as variable in the model. The model expresses aggregate output as a function of capital stock, labour force and technology as depicted below;

$$Y = K^{\propto}(AL)^{1-\propto} \quad [1]$$

Equation [1] is transformed as follows;

$$\ln Y = \ln A + \propto \ln K + 1 - \propto \ln L.........[2]$$

Estimating in logarithmic form, the model is expressed as;

$$\ln Y = \ln A + \propto \ln K + \beta \ln L + \varepsilon it.........[3]$$

where Y denotes economic growth, represented by food production, A is an index of technological progress which measures efficiency of labour (L) and capital (K) while ε_{it} denotes the error term .

3.2 Model Specification

The method of analysis used in this study was Autoregressive Distributed Lag (ARDL). The ARDL approach is considered more appropriate for this study because of its several advantages. First, it is the most appropriate technique that can effectively handle both the short and long-term dynamics. Second, ARDL effectively handles small sample size and endogeneity issue. Finally, it yields consistent results irrespective of whether the variables have mixed integration order, provided none is integrated at order 2. Our dataset are annual, showcasing that ARDL is potentially appropriate for this specific data structure.

The model for this study is adopted from the work of Adesete *et al*. (2023) but with some modifications in terms of variables used. As a departure, we measure climate change like Salisu and Oloko (2023) using two indicators; average temperature anomaly and carbon emission (CO_2) serving as explanatory variables. We use food production index as our dependent variable because it provides a perfect measure of food security as used in most literature, terrorism index is used as mediating variable while population growth rate and GDP per capita serving as control variables. We specify the model as follows:

FPI=f(TEMP, CO_2, GTI, PGR, GDPPC)---------------------------------------[4]

Econometric specification of the model in Equation [4] is re-specified as follows:

FPI= $\delta_0 + \delta_1$ TEMP + δ_2 CO_2 +δ_3 TI + δ_4 PGR + δ_5GDPPC+μ [5]

The ARDL model specification for this study is given as follows:

$$\Delta Fpi_t \equiv \lambda_0 + \lambda_1 Fpi_t + \Delta\lambda_2 Temp + \Delta\lambda_3 C02 + \Delta\lambda_4 Ti + \Delta\lambda_5 Pgr + \lambda_6 Gdppc$$

$$+ \sum_i^q \lambda_1 Fpi + \sum_i^r \lambda_2 Temp + \sum_i^s \lambda_3 C02 + \sum_i^t \lambda_4 Ti +$$

$$\sum_i^u \lambda_5 Pgr + \sum_i^v \lambda_6 Gdppc + \theta ECM + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [6]$$

Interactive model to capture the mediating effect of terrorism is specified as follows;

$$\Delta Fpi_t \equiv \lambda_0 + \lambda_1 Fpi_t + \Delta\lambda_2 Temp + \Delta\lambda_3 C02 + \Delta\lambda_4 Ti + \Delta\lambda_5 (Temp * Ti) + \Delta\lambda_6 (CO2 * Ti) +$$

$$\Delta\lambda_7 Pgr + \lambda_8 Gdppc + \sum_i^q \lambda_1 Fpi + \sum_i^r \lambda_2 Temp + \sum_i^s \lambda_3 C02 + \sum_i^s \lambda_4 (Temp * Ti) +$$

$$\sum_i^s \lambda_5 (CO2 * Ti) + \sum_i^t \lambda_6 Ti + \sum_i^u \lambda_7 Pgr + \sum_i^v \lambda_8 Gdppc + \theta ECM + \varepsilon_t \text{````````````````````````````````} [7]$$

where FPI represents food production index, TEMP denotes global average temperature anomaly (measured in degree centigrade °C), CO_2 is carbon dioxide emission (measured in metric tons per capita), TI denotes terrorism index used to capture the impact of terrorism, PGR represents population growth rate, and GDPPC is gross domestic product per capita. The coefficients are $\lambda_1 - \lambda_6$ while λ_0 denotes constant intercept, **φ** is the coefficient of the error correction component and $\mathcal{E}_t$ is the stochastic error term.

3.3 Variable Measurement and A priori Expectation

We measured climate change using two indicators; annual average temperature anomaly (measured in oC), and CO_2 emission, measured in metric tons per capita. In addition, food production index was used as proxy for food security while terrorism index used as proxy for violent crimes. Based on economic theory, population growth is expected to have an inverse relationship with food security, suggesting that population growth dampens food security. The expected sign of GDP per-capita is positive but terrorism index would be negative, implying that these variables negatively affect food security. Temperature anomalies and CO_2 emissions are expected to have a negative sign.

3.4 Data Sources

Dataset used in this study are annual data, spanning from 1990-2024.This period marked the most intensified terrorist attacks which adversely affect food production in major parts of the country. Data on climate change variables (average temperature anomaly and CO_2) is obtained from World Bank climate change knowledge portal, while data on terrorism index, food production index and population growth rate are retrieved from World Bank, World Development Indicator online database. Data on GDP per-capita is obtained from Central Bank of Nigeria Statistical Bulletin online database.

4. EMPIRICAL RESULTS AND DISCUSSION

Before computing the ARDL regression results, we first carried out some pre-estimation analysis to avoid spurious regression results. In doing so, we employed two stationarity tests: Augmented Dickey Fuller (ADF) and (Phillips-Peron (PP). The results of descriptive statistics and stationarity test are presented in Table 1and 2.

Table 1: Descriptive Statistic Results

TEST-	VARIABLE					
STATISTIC	FPI	TEMP	C02	TI	PGR	GDPPC
Mean	25083.51	53.70469	5577.507	25.52250	46785.82	18.45813
Median	22060.99	51.33800	3698.690	20.18000	65185.76	17.77000
Std. Dev.	19449.18	8.878883	4321.635	22.95104	30791.31	3.474907
Skewness	0.300990	1.518942	0.979388	0.441833	-0.783605	1.184430
Kurtosis	2.178178	4.522839	3.167317	1.814201	1.666146	5.581507
Jarque-Bera	6.447022	15.39704	5.153068	2.915979	5.647088	16.36757
Probability	0.500650	0.000453	0.076037	0.232704	0.059395	0.000279

Source*:* Authors' computations

Table 2: Unit Root Test

Variables	*ADF*	Remark	*PP*	Remark
FPI	3.27***	1(1)	5.53***	1(1)
TEMP	4.01*	1(0)	4.59*	1(0)
C02	5.31***	1(1)	4.25***	1(1)
TI	4.17***	1(1)	6.24***	1(1)
PGR	5.59**	1(1)	7.01**	1(1)
GDPPC	4.29**	1(0)	5.38**	1(0)

Note: *, ** and *** denote 10%, 5% and 1% significance levels respectively

Source: Authors' computation

Table 3: Bounds Test Results

Model	**F-Statistic**	**Upper Bound 1(1)**	**Lower Bound 1(0)**
*(F(FPI|TEMPC02 TIPGR GDPPC))****	6.526815		
Critical Values			
10%		3.00	2.08
5%		3.38	2.39
1%		4.15	3.08

Source: Authors' computations

Our descriptive statistics in *Table 1* indicate that all the series appear to be positively skewed with the exception of population growth rate (PGR). Meaning there is asymmetry in the distribution. The Jarque-Bera values are higher than the Kurtosis values, thus providing evidence of normal distribution of our series. In addition, stationarity test results in *Table 2* show that the dependent variable FPI and other series, TI,C02, and *PGR*, are stationary at order I(1),while *GDPPC* and TEMP are stationary at level I(0), suggesting that the variables' levels of integration vary. This finding provides further evidence for the use of ARDL model as suggested by Pesaran *et a*l. (2001).

Furthermore, to determine whether the variables used in this study have any long-term relationships, we used bounds co-integration test. The results in *Table 3*, indicate that F-statistic is higher than the upper bounds critical value at 5% level showcasing long-term relationship among the selected variables.

Table 4: Estimated ARDL model

Dependent Variable: *FPI*

Variables	Coefficient	t-Statistic	Prob.
	Short-run		
D(TEMP)*	-0.162103	-2.343804	0.0323
D(TEMP(-1)) **	-0.142050	-2.221090	0.0402
D(C02) **	-2.126622	-2.125026	0.0495
D(C02(-1)) **	-0.215332	-1.874743	0.0158
D(TI) **	-0.771196	-2.987631	0.0038
D(TI(-1)) **	-0.314714	-2.263712	0.0312
D(PGR(-1)) **	-0.417484	-1.630253	0.1204
D(GDPPC) **	0.831096	2.231574	0.0403
ECT***	-0.576110	-5.474699	0.0000
	Long-run		
TEMP*	-0.042064	-3.791155	0.0026
C02***	-10.65526	-2.582300	0.0170
TI**	-1.377094	-2.444169	0.0257
PGR***	-2.839062	-3.461419	0.0028
GDPPC**	1.061804	2.043539	0.0578
C***	61.466314	1.703108	0.1026
	Diagnostic test		
Serial correlation	0.51^{p}		
Heteroscedasticity	0.28^{p}		
Ramsey Test	0.59^{p}		
Normality Test	0.09^{p}		
Endogeneity	0.540^{p}		

Notes:H_0: variables are exogenous

*Asterisks***, ** and * explain 1%, 5% and 10% significance level*

^{p} *indicates probability value*

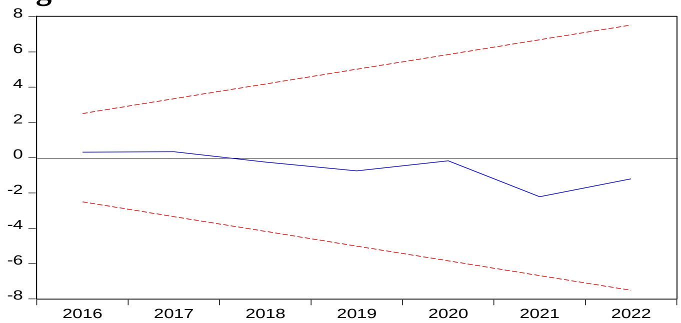
Source: Authors' computations

The estimated ARDL model's results are presented in *Table 4*. In the short term, the average temperature and carbon emission (C02) negatively influenced food security. The result suggests that climate change has detrimental effect on food security. The implication of this finding is that agriculture in Nigeria is vulnerable to climate change, extreme temperature and C02 emission negatively affects agricultural output. This result corroborates with submissions by Agu *et al*. (2021) and ImandoJemu *et al*. (2024) .The lagged value of TI is negatively related to FPI, meaning that given a 1% variation in TI, food security will reduce by approximately 0.31%. This finding was confirmed by the works of Weldegiagis *et al.* (2023). The finding also indicate that population growth is inversely correlated with food security. This suggests that for every one unit change in PGR, FPI would be negatively affected by that change. The regression results show that in the short run per-capita income positively affect food production index. From this regression result, we discover that if GDP per-capita increases by 1%, averagely, food security goes up by approximately 0.83%. Similar results were discovered by Adom, *et al.* (2023) and Imen and Abdelkarim (2023). The estimated coefficient of error correction term of -0.57 was significant at the 5 percent level, and appropriately negatively signed, indicating that about 57 percent of any disequilibrium would be easily corrected in a short period of time. This shows a very high speed of adjustment to equilibrium after a shock.

In the long-term, average temperature and C02 emission negatively and significantly affect food security, showcasing that excessive temperature and C02 are detrimental to food security. The relationship between TI and FPI is negative and significant, meaning that terrorism significantly affects food security. The import of this analysis is that conflict occasioned by Boko Haram terrorists and banditry potentially leads to supply chain disruption and exacerbating food security challenges in the country. This result was confirmed by the studies of Okafor *et al.*, (2024) In addition, population growth is found to be negatively related to FPI, meaning that increased POP growth raises food demand and escalation of food prices, thereby exacerbating food security challenges. Adesete *et al.* (2023), found similar results. We also discovered that GDP per capita had a significant positive impact on food security, suggesting that increased GDPPC leads to increase in consumers' purchasing power, leading to increased food insecurity.

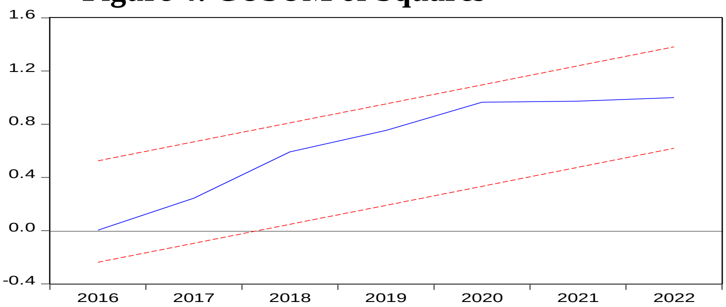
The diagnostic test findings in *Table 4* show that the model did not have autocorrelation issue because the probability value of serial correlation LM test is 0.51 and this is higher than 0.05. The model also does not have a heteroskedasticity issue. We also discover that the model does not suffer misspecification bias. Normality test indicates that the residuals are normally distributed. The residual test based on CUSUM (Cumulative sum) and the CUSUM-SQ (Cumulative sum of squares) indicates that our model was stable. The results in Table 4 also confirm that there is no endogeneity issue among the variables, with p-value of 0.540 that is statistically insignificant, suggesting that ARDL is appropriate for the study.

Figure 3: CUSUM



Source: Authors' computation

Figure 4: CUSUM of Squares



Source: Authors' computations

5. CONCLUSION AND POLICY RECOMMENDATION

In this paper, the impact of climate change and terrorism on food security in Nigeria has been extensively discussed using annual data from 1990-2024.We hypothesize that terror attack and climate change do not significantly induce food security in Nigeria. Using ARDL method, our results confirmed that both climate change and terrorism exert negative impact on food security in Nigeria, suggesting that these variables are detrimental to food security. We also confirmed that population growth rate has strong negative effects on food security. Conversely, GDP per capita positively and significantly improved food security in Nigeria for the period of examination. These findings were in line with economic theory and submission of many scholars such as Adom, *et al.* (2023), Imen and Abdelkarim (2023), Abbah *et al*. (2025). On the basis of our findings, the paper concludes that extreme climate conditions and terrorism have detrimental effects on food security in Nigeria during the study period.

Our empirical evidence has policy implications. Our findings confirm that temperature anomaly and CO_2 emissions negatively influenced food security. In addition, terrorism exerts a strong negative impact on food security. Based on our findings, the paper recommends the following;

1. Government and policy analysts should adopt climate mitigation strategies aimed at reducing carbon emission in order to ensure adequate and sustainable food supply for the country's growing population.
2. Climate smart agricultural technologies should be implemented and sustained in order to improve environmental quality and sustainable food production in Nigeria.
3. Government should beef up the security to tackle the menace of terrorism in Nigeria and other developing countries.

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