

Insecurity and Food Production in Nigeria

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ABSTRACT

Nigeria continues to experience persistent food insecurity arising from escalating insecurity, climate variability, and inadequate investment in agricultural development. These challenges have constrained agricultural productivity and threatened national food security. In response, successive governments have implemented agricultural policies and intervention programmes, including increased agricultural spending, transformation initiatives, input subsidies, and investments in research and rural infrastructure. Despite these efforts, food production remains inadequate due to persistent insecurity and climate related challenges. Thus, this study examined the impact of insecurity on food production in Nigeria, with emphasis on terrorism, agricultural research and development (R&D), and climate change. Annual time series data spanning from 1990 to 2024 were analysed using the Johansen cointegration technique, Vector Error Correction Model (VECM), impulse response functions, and forecast error variance decomposition. Food production index served as the proxy for food production, while the terrorism index, government capital expenditure on agriculture, and average annual rainfall represented insecurity, agricultural R&D, and climate change, respectively. The findings reveal that terrorism exerts a negative and significant effect on food production in both the short and long run. Government capital expenditure on agriculture positively and significantly improves food production in the short run but has an insignificant long-run effect. Average annual rainfall exerts a positive and significant long-run effect, although its short-run impact is insignificant. Similarly, impulse response analysis further confirms the persistent adverse effect of terrorism on agricultural output. The study concludes that improving food production requires enhanced security, sustained agricultural investment, and climate adaptation. It recommends strengthening security in farming communities, expanding agricultural R&D, and promoting climate resilient practices through irrigation, improved weather forecasting, and drought resistant crop varieties.

Keywords: Terrorism, Food, Production, Climate Change, Agriculture

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1. Introduction

Food security has become a major global development priority, featuring prominently in the Sustainable Development Goals (SDGs), particularly SDG 2, which seeks to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture by 2030 (United Nations, 2015). Similarly, the African Union Agenda 2063 recognizes agricultural transformation as a critical driver of economic growth, poverty reduction, and sustainable development across Africa (African Union, 2015). The Food and Agriculture Organization (FAO, 1996) defines food security as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food for an active and healthy life. Achieving this objective depends on four interrelated dimensions, including food availability, accessibility, utilization, and stability, all of which are fundamentally supported by sustainable food production. Food production remains the cornerstone of food security as it determines the availability of food and influences access, nutritional outcomes, and supply stability. In particular, agricultural productivity is shaped by several factors, including

technological innovation, research and development, infrastructure, climatic conditions, land quality, and human capital. However, in many developing economies, particularly Nigeria, insecurity has emerged as one of the most significant constraints to agricultural production. While climate variability and inadequate technological adoption continue to affect farming activities, persistent violence has increasingly disrupted agricultural systems, reduced cultivated farmland, displaced farming households, and weakened food supply chains (Jones et al., 2017). Consequently, improving food production requires not only enhanced agricultural investment but also a secure environment that enables farmers to undertake production activities without fear.

In Nigeria, the country possesses considerable agricultural potential, including vast arable land, favourable agro-ecological conditions, and a large agricultural labour force capable of supporting domestic food production and export growth (FAO, 2023). Agriculture has historically remained an important contributor to employment, rural livelihoods, and national output, accounting for a significant share of employment and serving as the primary livelihood for rural households (World Bank, 2023). Nevertheless, the sector has experienced declining productivity due to structural constraints such as inadequate infrastructure, weak agricultural research and extension systems, climate variability, limited mechanization, and increasing insecurity (Villacis et al., 2022). Terrorism in the North-East, banditry and kidnapping in the North-West, and recurrent farmer–herder conflicts across the Middle Belt have significantly disrupted farming activities by destroying farmlands, displacing rural communities, restricting access to agricultural land, interrupting transportation networks, and increasing post-harvest losses (Adewumi & Omilola, 2016). Consequently, agricultural output has declined, food prices have risen sharply, with food insecurity worsened across the country (FAO & World Food Programme, 2023).

Recognizing the strategic importance of agriculture to national development, successive Nigerian governments have implemented several agricultural policies and intervention programmes aimed at increasing food production and achieving food security. Early initiatives such as the National Accelerated Food Production Programme (NAFPP), Operation Feed the Nation (OFN), and the Green Revolution Programme sought to modernize agricultural production through improved inputs, extension services, and infrastructure. Following the return to democratic governance, additional programmes, including the Special Programme for Food Security (SPFS), Fadama Development Projects, the National Economic Empowerment and Development Strategy (NEEDS), the Agricultural Transformation Agenda (ATA), the Anchor Borrowers' Programme (ABP), and the National Agricultural Technology and Innovation Policy (2022-2027), were introduced to improve agricultural productivity through increased investment, credit support, irrigation development, agricultural research, and technology adoption. Despite these interventions, national food production has remained below the level required to satisfy Nigeria's rapidly growing population, largely because insecurity and climate related shocks continue to undermine the effectiveness of these policies.

Persistent insecurity trends further demonstrate the growing challenge facing Nigeria's agricultural sector. The escalation of Boko Haram insurgency, farmer-herder conflicts, banditry, and kidnapping have coincided with increasing food inflation, declining agricultural productivity, widespread displacement of farming communities, and rising levels of hunger. According to FAO (2024), millions of Nigerians continue to face acute food insecurity, while conflict affected regions account for a substantial proportion of abandoned farmlands and disrupted agricultural activities (National Bureau of Statistics, 2024). These developments suggest that improving food production requires a comprehensive understanding of both security and non-security determinants of agricultural performance. Although numerous studies have examined the relationship between insecurity and agricultural production in

Nigeria, most have concentrated on specific regions, particular forms of insecurity, or descriptive assessments of food security. Moreover, existing studies have paid limited attention to the complementary roles of agricultural research and development and climate change in shaping food production outcomes, while many rely on conventional econometric approaches that assume linear relationships among variables. This study therefore examines the impact of terrorism, agricultural research and development, and climate change on food production in Nigeria using annual data covering the period 1990-2024. The study employs the Johansen Cointegration technique, Vector Error Correction Model (VECM), impulse response analysis, and forecast error variance decomposition to evaluate both the short-run and long-run dynamics among the variables. The findings are expected to provide empirical evidence for designing integrated security, agricultural, and climate adaptation policies capable of enhancing food production and strengthening food security in Nigeria.

2. Literature Review

2.1 Theoretical Framework

This study is anchored on the Cobb-Douglas production function developed by Cobb and Douglas (1928), which explains output as a function of productive inputs. The theory posits that production results from the combination of labour, capital, land, and technology, with each input contributing to output. The standard Cobb-Douglas production function is expressed as:

$$Y = AK^{\alpha}L^{\beta} \quad 1$$

where Y represents output, A denotes total factor productivity or the level of technology, K represents capital input, L represents labour input, while α and β are the output elasticities of capital and labour respectively. Other relevant theories include:

2.1.1 Malthusian Theory

The Malthusian Theory, developed by Malthus (1798), argues that population tends to grow faster than food production, resulting in persistent pressure on available food supplies. According to the theory, food production increases at a slower rate than population growth, making food shortages inevitable unless agricultural productivity improves or population growth is moderated. Although subsequent studies have criticized this view for underestimating the role of technological progress in agriculture (Boserup, 1965; Simon, 1981), the theory remains relevant in explaining food insecurity where agricultural production is constrained by structural and environmental challenges. In the Nigerian context, the theory suggests that insecurity can further widen the gap between food demand and food supply by disrupting farming activities, displacing rural households, and reducing agricultural output. However, investments in agricultural research and development (R&D) can enhance productivity and partly offset these constraints through technological innovation. Consequently, the Malthusian theory provides a useful framework for examining how terrorism, agricultural research and development, and climate change influence food production in Nigeria.

2.1.2 Class Conflict Theory

The Class Conflict Theory, advanced by Marx and Engels (1848) and further developed by Marx (1867), explains that competition over economic resources and unequal access to productive assets generates social conflict. The theory argues that inequalities in the ownership and control of productive resources often give rise to violence and instability, which adversely affect economic activities and social welfare. Although subsequent scholars have emphasized additional sources of conflict beyond economic inequality (Weber, 1947; Dahrendorf, 1959), the theory remains useful in explaining conflicts arising from competition over scarce

resources. Within the Nigerian context, the theory provides a useful explanation for insecurity associated with terrorism, farmer-herder conflicts, banditry, and communal violence. These conflicts disrupt farming activities, destroy productive assets, displace farming communities, and reduce agricultural productivity. Consequently, the class conflict theory offers a sociological perspective for understanding how insecurity constrains food production and undermines food security in Nigeria.

2.1.3 Theory of Production

The theory of production, commonly represented by the Cobb-Douglas production function developed by Cobb and Douglas (1928), explains that output is determined by the combination of productive inputs such as labour and capital. The theory further recognizes that improvements in technology and productivity enhance output by increasing the efficiency with which these inputs are utilized. As a result, agricultural production depends not only on the quantity of productive resources but also on technological progress and the efficiency of resource utilization. In relation to this study, the theory suggests that food production depends on the effective use of agricultural inputs, while insecurity reduces productivity by limiting access to farmland, labour, and capital. Conversely, agricultural research and development enhances technological progress, improves resource efficiency, and increases agricultural output. The theory of production therefore provides an appropriate framework for analyzing how insecurity, research and development, and climate change jointly influence food production in Nigeria. Nicholson et al. (2021)

2.2 Empirical Review

The empirical evidence generally indicates that insecurity significantly constrains agricultural productivity and food production by disrupting farming activities, displacing farming households, destroying productive assets, and weakening agricultural supply chains. For instance, a work by Amadi-Robert et al (2024) examined the impact of insecurity on agricultural sector performance in Nigeria, using the Autoregressive Distributed Lag (ARDL) model. The study found a long-run relationship between insecurity and agricultural sector performance in Nigeria, although the effects of individual insecurity indicators differed. Similarly, Adelaja, & George, (2019), employing the ARDL and Error Correction Model (ECM), reported that terrorism significantly reduced agricultural output in both the short run and the long run. Comparable findings were reported by Ilesanmi and Odefadehan (2022) and Bello (2024), who found that insecurity, crime, and unemployment exert significant negative effects on agricultural productivity and food security in Nigeria.

Further evidence from advanced econometric studies reinforces these findings. Usman et al (2024), using the nonlinear Autoregressive Distributed Lag (NARDL) model, established significant asymmetric short-run and long-run effects of insecurity on agricultural productivity, indicating that changes in insecurity influence agricultural output disproportionately. Likewise, Thankgod and Nwikina (2024) found that kidnapping, armed robbery, and financial constraints significantly reduced agricultural GDP, suggesting that insecurity also weakens agricultural performance through the financial system. Evidence from survey-based and micro-level studies is equally consistent. Yusuf and colleagues (2018), Otuisi and colleagues (2023), Ijirshar and colleagues (2025), and Adelaja and George (2019) in separate studies found that insurgency, kidnapping, and communal conflicts substantially reduced agricultural production by displacing farmers, restricting access to farmland, and destroying productive assets. Similar conclusions were reached by Ubilava, Hastings, and Atalay (2022), Abdullahi, Kalengyo, and Warsame (2024), Hassen and El-Bilali (2024), and Kafando (2025), all of whom concluded

that conflict and political instability remain major constraints to agricultural productivity and sustainable food systems across Africa.

The empirical literature also demonstrates that agricultural research and development contributes positively to food production by promoting technological innovation, improving production efficiency, and strengthening farmers' adaptive capacity. In that, Tovilode and Moon (2025), using fixed-effects panel estimation for 49 low and middle-income countries, found that public agricultural R & D significantly improved cereal yields and agricultural productivity, particularly where institutional quality was strong. Similarly, Deng and colleagues (2024), employing panel econometric techniques across 48 countries, reported that technological innovation and knowledge spillovers significantly enhanced agricultural productivity. Country specific evidence further supports this relationship, as Hataminia and Khosravi (2025), using the ARDL model for Iran, found that agricultural R&D expenditure significantly increased agricultural value added in both the short run and the long run. Likewise, Ortiz-Bobea and colleagues (2024) concluded that sustained public investment in agricultural research is essential for maintaining long-term agricultural productivity and mitigating the adverse effects of climate change. Consistent with these findings, Amankwah (2023) reported that the adoption of improved agricultural technologies significantly enhanced farm productivity and strengthened farmers' resilience to climate variability in Nigeria.

In the same manner, empirical evidence on climate change likewise indicates that changing climatic conditions significantly influence food production and agricultural productivity. The studies include Adebayo and colleagues (2024), who used the ARDL model in its study and found that rising temperatures significantly reduced agricultural output in Nigeria, although rainfall produced mixed effects. Similarly, Abdullahi and Sadiq (2023) reported that increasing temperatures and irregular rainfall patterns significantly reduced crop productivity, while Ogundari (2021), using panel data across African countries, found that higher temperatures consistently depressed agricultural productivity. Other studies emphasize the effects of rainfall variability and extreme weather events. Ayanlade and colleagues (2020) found that changing rainfall patterns disrupted farming calendars and reduced crop output in Nigeria, whereas Egbetokun and colleagues (2022) reported that temperature and precipitation significantly reduced agricultural productivity across Sub-Saharan Africa. Similar conclusions were reached by Okorie and Nwachukwu (2023), Ibrahim and Usman (2020), and Lobell and colleagues (2020), all of whom concluded that climate change weakens food production.

This research work reviewed numerous related past studies on insecurity in relation to agricultural output performance (food production). However, these studies reported varying and contradicting findings. For instance, Adelaja and George (2019), Ilesanmi and Odefadehan (2022), Otuisi *et al.* (2023), Usman *et al* (2024), Abubakar Ahmed Bello (2024), and Thankgod and Nwikina(2024) revealed that insecurity such as kidnapping, armed robbery, Bokoharam, crime rate, terrorism index, negatively affect food production. In contrasts, Amadi-Robert *et al* (2024), and Yusuf *et al* (2018) established a strong positive correlation between agriculture sector performance (food production) and insecurity proxied kidnapping, armed robbery etc. In addition, prior studies used insecurity proxies but failed to consider the effect of R & D on food production. To close this gap in the literature, this study empirically investigated the impact of insecurity proxied by terrorism index, climate change proxied by average rainfall rate, and technological progress proxied by R & D on food production in Nigeria, which other studies failed to capture in their investigations.

3. Methodology

This research evaluates the effect of insecurity on food production in Nigeria. An ex-post facto research design is used, relying on secondary data that already exist and cannot be manipulated

by the researcher. The study specified a multiple regression model in which food production index is the dependent variable while insecurity (proxied by terrorism perception index), climate change (proxied by average rainfall) and research and development (as a proxy for technological advancement) were explanatory variables. The study used the autoregressive distributed lag (ARDL) regression model to analysed the data with the help of STATA 16.

3.1 Model specification

In the context of this study, food production is viewed as a function of factors that either enhance or constrain agricultural productivity. Consequently, the traditional Cobb-Douglas model was extended to incorporate insecurity, research and development (R&D), and climate change as determinants of food production, such that:

$$FPI = TI^{\beta_1}.RD^{\beta_2}.CC^{\beta_3}.FERT^{\beta_4}.AGL^{\beta_5}.e\mu \quad 2$$

Where, FPI = food production index (proxy for food production), TI = terrorism index (proxy for insecurity), RD = research and development as a proxy for technological advancement, CC = climate change, FERT = fertilizer application, AGL = agricultural land, and μ is the stochastic error term. Due to difficulty in obtaining data for agricultural or national research and development spending, the researcher used government capital expenditure on agriculture (GCEA) as proxy for the variable. Also, climate change is proxied by average rainfall rate (ARR). Hence,

$$FPI = TI^{\beta_1}.GCEA^{\beta_2}.ARR^{\beta_3}.FERT^{\beta_4}.AGL^{\beta_4}.e\mu \quad 3$$

Taking the natural logarithm of some of the variables yields the estimable long-run linear equation:

$$FPI_t = \beta_0 + \beta_1 TI_t + \beta_2 \ln GCEA_t + \beta_3 \ln ARR_t + \beta_4 FERT_t + \beta_5 AGL_t + \mu \quad 4$$

The model predicts that government capital expenditure on agriculture (proxy for research and development), fertilizer consumption, and agricultural land will have a positive effect on food production ($\beta_2 > 0$, $\beta_4 > 0$, $\beta_5 > 0$), while insecurity and climate change are expected to exert negative effects ($\beta_1 < 0$, $\beta_3 < 0$). The relevance of the Cobb–Douglas production function to this study lies in its ability to provide a robust analytical framework for examining how technological advancement, insecurity, and climatic conditions jointly influence food production in Nigeria.

3.2 Sources of Data

The study used annual time series data covering 1990 to 2024. The data on food production index, average rainfall rate, fertilizer consumption, and agricultural land were obtained from World Bank Development Indicators for 2025 (available at: <https://databank.worldbank.org/reports.aspx?source=2&series=SP.POP.TOTL>) while that of terrorism index was obtained for from Institute Economics and Peace (available at: <https://statbase.org/data/nga-global-terrorism-index>). Likewise, data on government capital expenditure on agriculture were obtained from the Central Bank of Nigeria Statistical Bulletin and CEIC databas <https://www.ceicdata.com>)

3.3 Estimation Procedure

The estimation procedure began with the investigation of the time series properties of the variables, using unit root tests, such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test, to determine their order of integration. These tests are followed by the used the Johansen cointegration test and Vector Error Correction Mechanism (VECM) to analyze the data. The VECM form of the model is:

$$\Delta FPI_t = \beta_0 + \lambda ECT_{t-1} + \sum_{i=1}^{p-1} \beta_{1i} FPI_{t-i} + \sum_{i=1}^{p-1} \beta_{2i} \Delta TI_{t-i} + \sum_{i=1}^{p-1} \beta_{3i} \Delta \ln GCEA_{t-i} + \sum_{i=1}^{p-1} \beta_{4i} \Delta \ln ARR_{t-i} + \sum_{i=1}^{p-1} \beta_{5i} FERT_{t-i} + \sum_{i=1}^{p-1} \beta_{6i} AGL_{t-i} + \varepsilon_t \quad 5$$

The cointegration test would be conducted through the use of the Johansen cointegration test, and the VECM, which were employed to capture both the short-run dynamics and the long-run equilibrium relationship between food production index (FPI), terrorism index (TI), government capital expenditure on agriculture (GCEA), annual rainfall (ARR), fertilizer consumption (FERT), and agricultural land (AGL). The error correction term (ECT) derived from the cointegrating equation measures the speed at which deviations from long-run equilibrium are corrected. A negative and statistically significant coefficient of the ECT indicates convergence toward long-run equilibrium following short-run shocks. Finally, diagnostic and stability tests were conducted to validate the model. These include tests for serial correlation, heteroskedasticity, normality, and model stability.

4. Results

4.1 Unit root test results

The study used the Dickey-Fuller and the Phillips-Perron methods to conduct the unit root test. The summary of each result is presented below.

Table 1: Summary of the Dickey-Fuller GLS unit root test result

Series	Test statistic	5% Critical value	P-value	Test statistic	5% Critical value	P-value	Order of Integration
				(1 st Difference)			
FPI	-0.327	-2.975	0.922	-10.900	-2.978	0.000	I(1)
TI	-0.939	-2.975	0.775	-5.975	-2.978	0.000	I(1)
lnGCEA	-2.252	-2.975	0.093	-4.451	-2.978	0.000	I(1)
lnARR	-2.475	-2.975	0.122	-7.787	-2.978	0.000	I(1)
FERT	-2.158	-2.975	0.222	-5.571	-2.978	0.000	I(1)
AGL	-2.063	-2.975	0.259	-3.643	-2.978	0.005	I(1)

Source: Researcher's computation (2026) from STATA 16

The Dickey-Fuller unit root test results in Table 1 reveal that all variables – food production index (FPI), terrorism index (TI), log of government capital expenditure on agriculture (lnGCEA), log of average rainfall (lnARR), fertilizer consumption (FERT) and agricultural land (AGL) – are non-stationary at level but become stationary at first differencing. In other words, all the variables are integrated of order one, I(1), which validates the use of cointegration techniques in the analysis. However, we also subjected the data to unit root test using the Phillips-Perron method to see if the same conclusion holds.

Table 2: Summary of Phillips-Perron unit root test result

Series	Test statistic (t)	5% Critical value	P-value	Test statistic (t)	5% Critical value	P-value	Order of Integration
				(1 st Difference)			
FPI	-0.106	-2.975	0.9488	-9.772	-2.978	0.0000	I(1)
TI	-0.957	-2.975	0.7688	-5.979	-2.978	0.0000	I(1)
lnGCEA	-2.471	-2.975	0.0932	-4.388	-2.978	0.0003	I(1)
lnARR	-2.385	-2.975	0.1460	-8.356	-2.978	0.0000	I(1)
FERT	-2.256	-2.975	0.1866	-5.567	-2.978	0.0000	I(1)
AGL	-1.987	-2.975	0.2921	-3.738	-2.978	0.0036	I(1)

Source: Researcher's computation (2026) from STATA 16

The Phillips-Perron unit root test results in Table 2 indicate that all variables are non-stationary at level but become stationary at first difference. Hence, all variables are integrated of order one, I(1), validating the application of cointegration techniques in the study. The result is consistent with the earlier Dickey-Fuller results and confirms that the variables satisfy the requirement for cointegration analysis. Hence, we employed the Johansen cointegration test and vector error correction mechanism (VECM) method to estimation the empirical model of the study.

4.2 Cointegration test and VECM results

Table 3: Result of Johansen cointegration test (Trace & Max-Eigenvalue tests)

5%					
maximum rank	parms	LL	eigenvalue	trace statistic	critical value
0	42	-147.34713	.	116.9723	94.15
1	53	-127.96845	0.69102	78.2149	68.52
2	62	-111.92927	0.62170	46.1366*	47.21
3	69	-98.234143	0.56395	18.7463	29.68
4	74	-91.414311	0.33855	5.1067	15.41
5	77	-89.024227	0.13485	0.3265	3.76
6	78	-88.860984	0.00984		

Source: Researcher's computation (2026) from STATA 16

The Johansen Trace cointegration test was employed to determine the existence of a long-run equilibrium relationship among food production index (FPI), terrorism index (TI), log of government capital expenditure on agriculture (lnGCEA), log of annual rainfall (lnARR), fertilizer consumption (FERT), and agricultural land (AGL) in Nigeria between 1990 and 2024. The results reveal that the trace statistics for ranks zero (116.9723) and one (78.2149) exceed their respective 5 percent critical values of 94.15 and 68.52. Consequently, the null hypotheses of no cointegration and at most one cointegrating equation are rejected. However, at rank two, the trace statistic of 46.1366 is lower than the critical value of 47.21, indicating failure to reject the null hypothesis. Thus, the test concludes that there are two cointegrating equations among the variables. This finding implies the existence of two long-run equilibrium relationships linking the variables of the study. The presence of cointegration justifies the use of the Vector Error Correction Model (VECM) to estimate both the short-run dynamics and long-run relationships among the variables. The VECM result is presented below.

Table 4: VECM long-run results

	beta	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
_ce1							
	fpi	1	.	.	.	.	.
	ti	-5.926969	2.554992	-2.32	0.020	.9192772	10.93466
	lngcea	-1.13476	2.693254	-0.42	0.674	-4.14392	6.41344
	lnarr	361.9043	62.80831	5.76	0.000	-485.0063	-238.8023
	fert	0.5590198	.3749482	1.49	0.136	-.1758651	1.293905
	agl	9.656139	2.415327	4.00	0.000	-14.39009	-4.922184
	_cons	3124.546	.	.	.	.	.

Source: Researcher's computation (2026) from STATA 16

The long-run coefficient of terrorism (TI) is negative (-5.926969) and statistically significant ($p = 0.020$), indicating that increased terrorist activities reduce food production in Nigeria. This supports the view that insecurity disrupts farming, displaces farmers, destroys agricultural assets, and discourages investment. Government capital expenditure on agriculture (lnGCEA) is negative (-1.13476) but statistically insignificant ($p = 0.674$), suggesting that public

agricultural spending has not significantly improved food production, possibly due to inadequate funding, poor policy implementation, corruption, and inefficient resource allocation. Annual rainfall (lnARR) has a positive (361.9043) and statistical significant ($p = 0.000$), implying that favourable rainfall substantially enhances agricultural productivity. Fertilizer consumption (FERT) has the expected positive (0.5590198) but insignificant ($p = 0.136$), indicating that its contribution to food production was not statistically strong during the study period. In contrast, agricultural land (AGL) has a positive (9.656139) and statistically significant effect ($p = 0.000$), showing that expanding agricultural land significantly increases food production in Nigeria.

Table 5: VECM short-run results

		Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
D_fpi	_ce1						
	LD.	-.1336939	.0567252	-2.36	0.018	-.2448731	-.0225146
	fpi						
	LD.	-.3760063	.1675253	-2.24	0.025	-.7043498	-.0476627
	ti						
	LD.	-4.466301	1.684988	-2.65	0.008	-7.768818	-1.163785
	lngcea						
	LD.	2.214408	1.041329	2.13	0.033	.1734406	4.255375
	lnarr						
	LD.	-9.183108	14.78824	-0.62	0.535	-38.16753	19.80131
	fert						
	LD.	-.0476375	.1736945	-0.27	0.784	-.3880724	.2927974
	agl						
	LD.	-1.303933	1.376212	-0.95	0.343	-4.001258	1.393392
	_cons	1.54888	1.27241	1.22	0.223	-.9449982	4.042758
R-Sq = 0.6574, $\chi^2 = 47.97499$, Sig. = 0.0000							

Source: Researcher's computation (2026) from STATA 16

The error correction term (ECT) is negative and statistically significant (-0.1337 ; $p = 0.018$), confirming a stable long-run relationship among the variables. The coefficient indicates that about 13.4% of deviations from equilibrium are corrected annually, implying full adjustment in approximately 7.5 years. In the short run, the lagged change in food production is negative and significant (-0.3760 ; $p = 0.025$), reflecting adjustment dynamics in agricultural output. Terrorism also has a negative and significant effect (-4.4663 ; $p = 0.008$), indicating that increased terrorist activities immediately reduce food production by disrupting farming, displacing rural populations, and restricting access to farmlands. Government capital expenditure on agriculture has a positive and significant effect (2.2144; $p = 0.033$), suggesting that public investment stimulates food production in the short run. However, annual rainfall, fertilizer consumption, and agricultural land are statistically insignificant, implying that their effects are stronger in the long run. The model explains 65.7% of the variation in food production ($R^2 = 0.6574$) and is jointly significant ($\chi^2 = 47.97$; $p = 0.000$), confirming the relevance of the explanatory variables in explaining food production.

The findings of this study provide important policy implications for improving food production and strengthening food security in Nigeria. The significant negative effect of terrorism indicates that restoring security should be a top priority for government. Strengthening intelligence gathering, expanding rural security operations, improving community policing, and resolving farmers-herders' conflicts will create a safer environment for agricultural production. In addition, policies aimed at reducing rural poverty, unemployment, and social exclusion should be intensified, as addressing these underlying drivers of insecurity will help reduce violent conflicts and promote sustainable agricultural development. Similarly, the positive but temporary effect of government agricultural expenditure suggests that public investment in agriculture should be strengthened and better managed to generate lasting productivity gains. Government should increase funding for agricultural research institutes, extension services, irrigation facilities, mechanization, and technology adoption while ensuring transparency, accountability, and effective implementation of agricultural programmes. Greater emphasis should be placed on innovation-driven agricultural policies capable of delivering sustained improvements in food production rather than short-term intervention programmes.

Furthermore, the positive long-run contribution of rainfall implies that climate adaptation policies should be strengthened to reduce agricultural vulnerability to weather variability. Government should invest in irrigation infrastructure, climate-smart agriculture, improved weather forecasting systems, drought resistant crop varieties, and water resource management to reduce dependence on rainfall and improve agricultural resilience. Strengthening farmers' access to climate information and modern farming technologies will further enhance productivity under changing climatic conditions. Generally, the findings suggest that achieving sustainable food production in Nigeria requires an integrated policy framework that simultaneously addresses insecurity, improves the efficiency of agricultural research and development expenditure, and strengthens climate adaptation measures. Such a coordinated approach will enhance agricultural productivity, improve food security, and support long-term economic development.

4.3 Model diagnostic test, variance decomposition, and impulse-response analysis

The researcher used the autocorrelation, heteroskedasticity, normality, and stability tests to evaluate the quality of the estimated VECM model. The results are summarized in Table 6.

Table 6: Summary of the diagnostic tests

Test	Null hypothesis	Test Statistics	Prob.	Conclusion
Serial correlation	No serial correlation	41.9641 (Chi ²)	0.2281	Accept Ho. No serial correlation.
Heteroscedasticity	No ARCH effects	0.011 (Chi ²)	0.9178	Accept Ho: No autocorrelation
Stability test	Model is stable	0.7894 (Eigen)	N/A	Accept Ho. Model is stable.
Normality	Residuals are normally distributed	0.048 (Jarque-Bera)	0.9764	Accept Ho. Normally distributed.

Source: Researcher's computation (2026) from STATA 16

The results in Table 6 show that the estimated VECM is free from autocorrelation and heteroskedasticity and is stable, indicating its reliability for predicting food production using the terrorism index and other explanatory variables. Having confirmed the model's adequacy, the impulse response and variance decomposition analyses were conducted, with the results presented below.

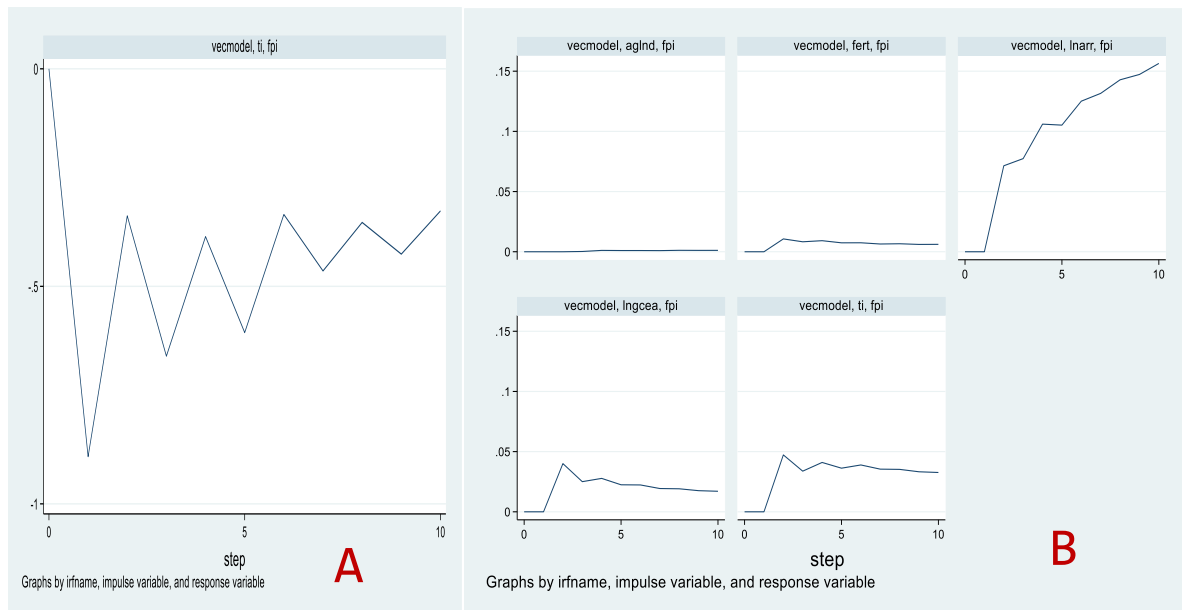


Fig. 1: Impulse-response and variance decomposition of FPI to TI

Source: Researcher's computation (2026) from STATA 16

Figure 1 above represents the Impulse response and variance decomposition of FPI to TI. The impulse response analysis (A) from the figure 1 shows that a positive shock to terrorism generates a persistent negative response in food production throughout the forecast period. The response declines sharply initially before gradually converging toward equilibrium but remains below zero, confirming that terrorism has a sustained adverse effect on food production. This supports the VECM results that insecurity disrupts farming activities, discourages agricultural investment, and threatens food security in Nigeria. Similarly, the impulse response analysis (B) indicates that annual rainfall exerts the strongest positive effect on food production, followed by government agricultural expenditure (a proxy for technological progress) and fertilizer consumption, while agricultural land contributes only marginally. Although the IRF shows a slight positive response to a terrorism shock, the VECM estimates confirm its significant negative effect. These findings underscore the need to strengthen climate resilience, increase effective agricultural expenditure, improve fertilizer access, and address insecurity to achieve sustainable food production and food security in Nigeria.

5. Discussion of Findings

The empirical findings indicate that terrorism, research and development proxied by government capital expenditure on agriculture, and climate change proxied by annual rainfall exert different effects on food production in Nigeria, reflecting the varying roles of security, public investment, and climatic conditions in agricultural productivity. The results show that terrorism has a negative and statistically significant effect on food production in both the short run and the long run. This implies that increasing terrorist activities reduce agricultural output by disrupting farming operations, displacing rural households, destroying farmlands, restricting access to agricultural inputs, and discouraging private investment in agriculture. The persistence of this adverse effect suggests that insecurity has become a major constraint to agricultural development and national food security. The findings are consistent with the studies of Usman *et al.* (2024), Amadi-Robert *et al.* (2024), and Otuisi *et al.* (2023), who reported that insurgency, banditry, kidnapping, and farmer-herder conflicts significantly reduce agricultural productivity. The result also agrees with the Food and Agriculture Organization (2022), which observed that prolonged insecurity across the Sahel region has weakened

agricultural systems and reduced food availability. Conversely, the finding differs from Martin-Shields and Stojetz (2019), who argued that improved security conditions, can facilitate agricultural recovery and productivity. From a theoretical perspective, the result supports the deprivation theory and class conflict theory, which explain that poverty, social exclusion, and competition over scarce resources intensify violent conflicts that ultimately undermine agricultural production.

The findings further reveal that government capital expenditure on agriculture, used as a proxy for research and development, has a positive and significant effect on food production in the short run but an insignificant effect in the long run. A rise in agricultural expenditure therefore stimulates food production immediately through investments in research, extension services, rural infrastructure, and agricultural intervention programmes. However, the insignificant long-run effect suggests that these benefits are not sustained, possibly due to inadequate funding, policy inconsistencies, corruption, weak institutional capacity, and poor implementation of agricultural programmes. This finding supports Tovilode and Moon (2025), Deng *et al.* (2024), and Amankwah (2023), who emphasized the importance of research, innovation, and technological development in improving agricultural productivity. However, it differs from Hataminia and Khosravi (2025) and Ortiz-Bobea *et al.* (2024), who found that sustained investment in agricultural research and technological innovation produces long-run improvements in food production. The result is consistent with the Cobb-Douglas production function, which emphasizes the contribution of capital and technology to output, and partially supports the endogenous growth theory by indicating that the long-run benefits of research and innovation depend largely on the effectiveness of government investment and institutional performance.

Similarly, climate change, proxied by annual rainfall, exerts a positive and significant effect on food production in the long run but an insignificant effect in the short run. This suggests that adequate and sustained rainfall enhances agricultural productivity over time, although short-term rainfall variations may not immediately influence output. The finding is consistent with Adebayo *et al.* (2024) and Ogundari (2021), who reported that adequate rainfall remains an important determinant of agricultural production despite climatic variability. However, the result contrasts with Abdullahi and Sadiq (2023), Ayanlade *et al.* (2020), Egbetokun *et al.* (2022), Okorie and Nwachukwu (2023), and Ibrahim and Usman (2020), who emphasized the adverse effects of climate change arising from rising temperatures, erratic rainfall, and extreme weather events. The difference is largely attributable to the proxy adopted in this study, which captures the beneficial effects of adequate rainfall rather than the broader consequences of climate change. The finding is consistent with the Cobb-Douglas production function, where favourable climatic conditions improve the productivity of agricultural inputs, and with the endogenous growth theory, which recognizes productivity improvements as essential for sustained increases in agricultural output.

6. Conclusion

Based on the findings, the study concludes that improving food production in Nigeria requires a combination of enhanced security, effective and sustained investment in agricultural research and development, and stronger climate adaptation strategies. Addressing insecurity, improving the efficiency of public agricultural expenditure, and promoting climate resilient agricultural practices will not only increase agricultural productivity but also strengthen national food security and support sustainable economic development in Nigeria.

Based on the findings of the study, the following recommendations are made to the policy-makers.

1. Government should strengthen security across agricultural communities by enhancing intelligence gathering, increasing security presence in farming areas, and implementing effective measures to resolve farmers-herders' conflicts. This will reduce terrorist activities, improve farmers' access to farmlands, and promote increased food production.
2. The government should also increase and ensure the effective utilization of capital expenditure on agriculture by allocating more resources to agricultural research, extension services, rural infrastructure, and technological innovation. In addition, stronger monitoring, transparency, and policy consistency should be adopted to ensure that agricultural investments generate sustained improvements in food production.
3. Government should strengthen climate adaptation strategies by expanding irrigation facilities, promoting climate-smart agricultural practices, improving weather forecasting services, and encouraging the adoption of improved and drought resistant crop varieties. These measures will reduce dependence on rainfall variability and enhance sustainable agricultural productivity and food security.

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