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Modeling The Dynamics of Interdependence between Agricultural Sub-Sectors and Economic Growth in Nigeria

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ABSTRACT

This study examined the dynamic interdependence between agricultural sub-sectors and economic growth in Nigeria using annual time-series data from 1993 to 2023. The study aimed at investigating the long-run and short-run relationship among Gross Domestic Product (GDP), crop production, livestock, and fishing within the Johansen Vector Error Correction Model (VECM) framework. Forestry was excluded from the multivariate analysis due to its integration of order two, I(2), which violates standard cointegration assumptions. The Augmented Dickey-Fuller (ADF) unit root test revealed that GDP, crop production, livestock, and fishing were integrated of order one, I(1). The Johansen cointegration test confirmed the existence of long-run equilibrium relationships among the variables. The estimated long-run co-efficients showed that livestock and fishing exert significant positive effects on economic growth, with livestock having the strongest growth elasticity. The finding revealed that crop production primarily functions as an intra-sectoral stabilizer rather than a direct long-run driver of GDP growth. The adjustment dynamics indicated that GDP significantly corrects short-run disequilibrium in the macroeconomic system, while crop production adjusts deviations within the agricultural sector. Diagnostic tests confirmed the stability, normality, and overall adequacy of the estimated model. In addition, the robustness of the results was validated using an Error Correction Model (ECM) with Newey-West HAC standard errors. The study concluded that agricultural sub-sectors exert heterogeneous effects on Nigeria's economic growth and therefore should not be treated as a single aggregate sector in policy formulation. Based on this, some recommendations were suggested, agricultural policies focusing on livestock value-chain development, sustainable fisheries management, and improved crop productivity to enhance economic growth, food security, and sustainable development in Nigeria.

Keywords: Agricultural sub-sectors, Economic growth, Johansen cointegration, VECM, Nigeria.

INTRODUCTION

Agriculture refers to the practice of cultivating the land for crop production and raising animals for various human needs. It is one of the oldest occupations known to mankind, dating back to early human existence. Despite the rise of modern civilization and industrial development, agriculture continues to play a vital role in the growth and sustainability of economies across the world [4]. Nigeria, the agricultural sector remains a cornerstone of economic development and industrialization. Its importance lies in its ability to provide food for the growing population, supply of raw materials to the manufacturing sectors, generate foreign exchange earnings, create employment opportunities, and sustain markets for industrial outputs [15]. Nigeria is naturally endowed with vast areas of fertile land and favorable climatic conditions for agriculture. As of 1990, the country had approximately 81 million hectares of arable land out of a total land area of 91 million hectares, with about 18 million hectares classified as permanent pasture suitable for livestock farming. These resources support the cultivation of a wide range of crops and the development of livestock, forestry, and fisheries sub-sectors [8]. Agriculture has historically served as the backbone of Nigeria's economy. Before the oil boom of the 1970s, the agricultural sector was the dominant contributor to GDP, employment, and foreign exchange earnings [12]. It has provided food for the growing population, raw materials for local industries, and accounted for over 70% of export earnings. Even though oil revenue gradually overshadowed agriculture in terms of national attention and investment, agriculture continues to play a vital role in sustaining the livelihoods of millions of Nigerians particularly in rural areas.

Today, the agricultural sub-sector remains a key component to Nigeria's non-oil economy, contributing approximately 25–30% to GDP annually and employing over 35% of the working population [16]. The sector includes four major components: crop production, livestock, fisheries, and forestry. Among these, crop production dominates, yet all sub-sectors are crucial for a resilient and diversified agricultural base. The sector also has strong linkages with other areas such as manufacturing (agro-processing), transportation, and trade, making it a central player in any sustainable economic development strategy. The agricultural sector is widely recognized as a driving force behind economic development, particularly in developing nations. In many low- and middle-income countries, agriculture forms the backbone of the economy, contributing significantly to food security, foreign exchange earnings, and rural development. According to [15], enhancing agricultural development remains one of the most effective strategies for reducing extreme poverty, promoting inclusive growth, and addressing the food demands.

Promoting agriculture is not just a policy choice; it is a strategic necessity for nation-building, particularly in the Global South. Improved agricultural performance, especially through gains in productivity, has been identified as a major pathway to poverty alleviation in developing economies [5]. This aligns closely with core macroeconomic objectives such as employment generation, income distribution, and price stability. Furthermore, demographic projections highlight a pressing urgency: the global population is expected to exceed 9 billion by 2050, with Nigeria alone projected to have over 400 million people by that time. This population surge will nearly double the demand for food and place even greater pressure on agricultural systems. According to [9], agriculture has historically been Nigeria's most vital sector, contributing significantly to national output, employment, and foreign exchange earnings. However, this dominance was not sustained. The downward trend in agricultural contribution is largely attributed to the oil discovery which marked a turning point in Nigeria's economic trajectory.

The emergence of the oil sector during this period shifted the country's economic focus, making petroleum the primary driver of growth. As oil revenues surged, investment and policy attention diverted from agriculture, leading to its gradual decline in productivity and relevance. The economy became heavily reliant on crude oil exports, rendering it vulnerable to external shocks and global oil price fluctuations. Over time, this over-dependence eroded the gains previously made by the agricultural sector and weakened its ability to support economic development.

Statement of the Problem

Despite agriculture's significant potential for employment generation, food security, and economic diversification in Nigeria, the sector continues to experience low productivity due to poor infrastructure, low mechanization, policy inconsistency, and insecurity. Most government agricultural policies adopt a uniform approach, treating agriculture as a single sector despite the differing characteristics and economic contributions of crops, livestock, fisheries, and forestry. In addition, many previous empirical studies rely on aggregated agricultural data, thereby concealing the distinct effects of individual sub-sectors on economic growth. Consequently, there is limited empirical evidence on the dynamic short-run and long-run relationship between agricultural sub-sectors and economic growth in Nigeria. This study therefore, seeks to address this gap through a disaggregated econometric analysis of agricultural sub-sectors and economic growth in Nigeria.

Objectives of the Study

The broad objective of this study is to model the dynamic interdependence between agricultural sub-sectors and economic growth in Nigeria. The specific objectives are to:

1. Determine the stochastic properties and integration orders of agricultural sub-sectoral output and GDP series in Nigeria.

2. Estimate the long-run elasticities of GDP with respect to individual agricultural sub-sectors.

3. Quantify the speed and direction of adjustment toward long-run equilibrium following short-run disequilibrium.

4. Identify which agricultural sub-sectors function as direct growth drivers and which serve as intra-sectoral stabilizers within Nigeria's agricultural-growth nexus.

Research Questions

1. What is the time-series properties and integration orders of agricultural sub-sectoral output and GDP in Nigeria?

2. What are the long-run elasticities of GDP with respect to crop production, livestock, and fishing in Nigeria?

3. At what speed and through which variables do the system correct deviations from long-run equilibrium?

4. Which agricultural sub-sectors operate as direct drivers of economic growth, and which function primarily as stabilizers of intra-sectoral composition?

Research Hypotheses

Hypothesis 1:

H_o: There is no cointegrating relationship between agricultural sub-sectors and economic growth in Nigeria.

H_1: At least one cointegrating relationship exists between agricultural sub-sectors and economic growth in Nigeria.

Hypothesis 2:

H_o: Individual agricultural sub-sectors (crop production, livestock, and fishing) do not exert statistically significant long-run effects on GDP.

H_1: At least one agricultural sub-sector exerts a statistically significant long-run effect on GDP.

Hypothesis 3:

H_0: The speed of adjustment to long-run equilibrium is zero (no error-correcting mechanism exists).

H_1: The speed of adjustment to long-run equilibrium is statistically significant and negative (error correction occurs).

Hypothesis 4:

Ho: Agricultural sub-sectors exert uniform effects on Nigeria's economic growth.

H_1: Agricultural sub-sectors exert heterogeneous effects on Nigeria's economic growth, with distinct roles as growth drivers versus compositional stabilizers.

LITERATURE REVIEW

Theoretical and Conceptual Framework:

The relationship between agriculture and economic growth has long occupied a central position in development economics. Classical development theorists such as [17] and [15] argued that agriculture serves as a fundamental driver of structural transformation by supplying food, labor, capital, and raw materials required for industrial expansion. Within this framework, agricultural productivity growth stimulates economic development through

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employment generation, income redistribution, rural development, and increased domestic demand for industrial goods. The Agricultural-Led Growth Hypothesis further posits that improvements in agricultural productivity generate strong multiplier effects capable of accelerating long-run economic growth, particularly in developing economies where agriculture constitutes a substantial share of employment and national output [31]. In Nigeria, agriculture remains a major component of the non-oil economy, contributing significantly to Gross Domestic Product (GDP), food security, poverty reduction, and rural livelihoods [20].

Modern endogenous growth theory emphasizes that technological innovation, human capital accumulation, infrastructure development, and sector-specific investments influence long-run growth trajectories [28]. Applied to agriculture, this perspective suggests that different agricultural sub-sectors may exert heterogeneous effects on economic growth depending on their production linkages, technological intensity, and market integration. Consequently, disaggregating agriculture into crop production, livestock, fisheries, and forestry becomes necessary for understanding the distinct transmission mechanisms through which agricultural activities affect macroeconomic performance. Despite Nigeria's abundant agricultural resources, the sector continues to face structural constraints such as inadequate infrastructure, low mechanization, weak access to credit, climate-related shocks, insecurity, and policy inconsistency [11] In addition, excessive dependence on crude oil exports has contributed to the neglect of agriculture through the Dutch Disease phenomenon, whereby resource booms reduce investment and competitiveness in non-oil sectors [25]. These structural challenges have contributed to fluctuations in agricultural productivity and weakened the sector's overall contribution to sustainable economic growth.

Empirical Review

Several empirical studies have examined the relationship between agriculture and economic growth in Nigeria and other developing economies. However, the findings remain mixed due to differences in methodology, data coverage, model specification, and the level of agricultural aggregation employed. [4] investigated sectoral contributions to economic growth in Nigeria using time-series analysis and reported that agricultural output exerts a significant positive effect on GDP growth. Their findings emphasized the importance of increased investment in rural infrastructure, extension services, and agricultural modernization. Similarly, [1] employed a Vector Error Correction Model (VECM) to analyze the agriculture-growth nexus in Nigeria and found that agricultural activities maintain strong long-run relationships with economic growth despite weak short-run dynamics caused by market instability and climatic variations.

In a related study, [8] argued that agricultural transformation remains essential for structural economic development in Africa. Their study emphasized that productivity improvements in agriculture create important spillover effects for manufacturing, agro-processing, and trade. Likewise, [23] observed that agro-processing and agricultural value addition significantly enhance the sector's contribution to economic growth by improving market efficiency and reducing post-harvest losses. Recent studies focusing on agricultural sub-sectors have produced divergent findings regarding the relative contributions of crops, livestock, fisheries, and forestry to economic growth. For instance, [24] reported that crop production and livestock exert stronger positive effects on Nigeria's GDP due to their broad domestic consumption base and extensive production linkages. Similarly, [19] in a study on agricultural transformation in South Africa, found that livestock development contributes significantly to employment generation, food security, and rural income growth.

Conversely, some empirical studies suggest that fisheries and forestry remain underperforming due to weak institutional support, environmental degradation, and insufficient investment. FAO (2024) noted that Nigeria's fisheries sub-sector continues to experience productivity constraints associated with poor storage infrastructure, overfishing, inadequate financing, and climate-related environmental risks. [22] further argued that forestry development in many African economies remains constrained by unsustainable exploitation practices and weak environmental regulation frameworks. Although existing studies generally confirm the positive role of agriculture in economic growth, important gaps remain unresolved. Most previous studies rely on aggregate agricultural indicators, thereby masking the heterogeneous effects and adjustment dynamics of individual agricultural sub-sectors. Furthermore, limited attention has been given to the existence of multiple long-run equilibrium relationships among crop production, livestock, fisheries, and economic growth within a multivariate cointegration framework.

Research Gap

Despite extensive studies on agriculture and economic growth in Nigeria, most existing studies treat agriculture as a single aggregate sector, thereby masking the distinct contributions of crop production, livestock, fisheries, and forestry. In addition, limited studies have examined the dynamic long-run and short-run relationships among agricultural sub-sectors and economic growth using a multivariate cointegration framework. This study addresses these gaps by employing the Johansen Vector Error Correction Model (VECM) to investigate the dynamic interdependence between agricultural sub-sectors and economic growth in Nigeria from 1993 to 2023.

MATERIALS & METHODS

Data and Variables

This study utilises annual time-series data for Nigeria spanning 1993–2023 to examine the relationship between agricultural sector performance and economic growth. Gross Domestic Product (GDP) is specified as the dependent variable, while the explanatory variables include Crop Production, Livestock, Forestry, Fishing, and aggregate Agriculture. All variables are measured in nominal terms (₦, millions). Data are obtained from the Central Bank of Nigeria (CBN) Statistical Bulletin and the National Bureau of Statistics (NBS) annual reports. The sample period reflects the availability of consistent sectoral disaggregation and captures key macroeconomic episodes, including the post-Structural Adjustment Programme era, the 2014 GDP rebasing, and the post-COVID-19 recovery phase.

All variables are transformed into natural logarithms to stabilise variance and permit elasticity interpretation. First differences of the logged series approximate growth rates. To avoid perfect multicollinearity, aggregate agriculture is excluded from the multivariate specification, given its definitional dependence on sub-sector components. A supplementary bivariate model is estimated for the agriculture-GDP nexus.

Econometric Framework:

The empirical analysis proceeds sequentially. Descriptive statistics are first computed to summarize distributional characteristics. Stationarity is examined using the Augmented Dickey-Fuller (ADF) test [19], including both intercept and trend, with lag length selected via the Schwarz Bayesian Information Criterion (SBIC). Variables integrated of order one, I(1), are retained for cointegration analysis, while higher-order integrated series are excluded. The optimal lag length for the underlying Vector Autoregression (VAR) is selected using LR, FPE, AIC, HQIC, and SBIC criteria. Based on this, a Vector Error Correction Model (VECM) is estimated. The [14] procedure is employed to test for long-run relationships using trace and maximum eigenvalue statistics, with critical values from [18]. Where inference diverges, model selection prioritises economic interpretability and statistically significant adjustment coefficients [16]. Error-correction coefficients capture the speed of adjustment toward long-run equilibrium. A negative and significant coefficient indicates convergence, with magnitude reflecting adjustment speed.

Diagnostic and Robustness Tests:

Model adequacy is evaluated using the Lagrange Multiplier (LM) test for serial correlation [6]; [12]; the Jarque-Bera test for normality [13], and eigenvalue stability conditions. Goodness-of-fit is assessed using R^2 and joint χ^2-statistics. Robustness is examined using the [10] two-step error correction approach. The long-run residual is included in a short-run dynamic model, with standard errors corrected using the [21] HAC estimator.

Treatment of Non-Stationary Series:

The forestry variable is excluded from the multivariate analysis as it is integrated of order two, I(2), violating standard cointegration assumptions [27]. A separate bivariate analysis is conducted for completeness. All estimations are performed using Stata 15, with significance evaluated at the 1%, 5%, and 10% levels.

DATA ANALYSIS & DISCUSSION OF RESULTS

Table 1: Descriptive Statistics of Variables (1993–2023)

Variable	Mean	Median	Std. Dev.	Min.	Max.	Skewness	Kurtosis	Obs.
GDP	62,813.18	39,542.43	64,835.39	1,244.80	229,912.90	1.00	3.00	31
Agriculture	14,497.16	10,100.33	14,826.40	295.32	53,273.14	1.14	3.38	31
Crop Production	12,863.73	9,039.63	13,198.77	249.20	47,779.28	1.15	3.45	31
Livestock	985.03	758.84	830.00	36.58	2,620.29	0.43	1.69	31
Forestry	136.41	108.10	120.14	3.97	432.62	0.65	2.38	31
Fishing	490.62	193.75	702.74	5.59	2,335.49	1.77	4.82	31

The descriptive statistics for the period 1993-2023 reveal a Nigerian economy characterised by rapid expansion and substantial structural heterogeneity across agricultural sub-sectors. GDP averaged ₦62.81 trillion, ranging from ₦1.24 trillion in 1993 to ₦229.91 trillion in 2023, reflecting more than 180-fold growth over three decades. Within agriculture, which averaged ₦14.50 trillion, crop production dominates overwhelmingly at ₦12.86 trillion (approximately 89% of total agricultural output), while livestock (₦985.03 million), fishing (₦490.62 million), and forestry (₦136.41 million) constitute considerably smaller shares, consistent with Nigeria's smallholder crop-farming structure. All variables exhibit positive skewness and large standard deviations relative to their means, with fishing displaying the most extreme distributional characteristics skewness of 1.77 and kurtosis of 4.82indicating a leptokurtic distribution prone to sporadic large expansions, likely linked to environmental variability and intermittent policy interventions. In contrast, livestock (kurtosis = 1.69) and forestry (kurtosis = 2.38) exhibit platykurtic distributions with fewer extreme observations, reflecting longer production cycles and slower adjustment to economic stimuli than annual cropping. These divergent distributional patterns validate both the logarithmic transformation employed to satisfy normality assumptions in the Johansen framework and the disaggregated modelling strategy, as an aggregate agricultural variable would mask the fundamentally distinct stochastic processes driving individual sub-sector dynamics. The substantial gap between mean and median values across all series further signals the presence of deterministic structural shifts over the sample period, underscoring the appropriateness of a cointegration methodology that distinguishes long-run equilibrium relationships from short-run transitional dynamics.

Table 2: Augmented Dickey-Fuller (ADF) Unit Root Test Results

Variable	Level ADF	p-value	1st Diff ADF	p-value	2nd Diff ADF	p-value	Order
ln_gdp	-2.283	0.1774	-4.700	0.0001			I(1)
ln_agriculture	-1.981	0.2950	-4.782	0.0001			I(1)
ln_cropproduction	-1.961	0.3038	-4.688	0.0001			I(1)
ln_livestock	-2.436	0.1320	-3.791	0.0030			I(1)
ln_forestry	-1.117	0.7084	-2.429	0.1338	-4.464	0.0002	I(2)
ln_fishing	-1.598	0.4846	-4.475	0.0002			I(1)

ADF tests reveal a mixed integration order across the six variables. All series are non-stationary in log-levels ($p > 0.05$), consistent with their exponential growth paths and confirming that OLS in levels would be spurious. Five variablesln gdp, ln_agriculture, ln_cropproduction, ln_livestock, and ln_fishing become stationary upon first differencing ($p < 0.01$), confirming I(1) and satisfying the necessary condition for Johansen cointegration.

In forestry, however, requires second differencing ($p = 0.0002$) and is therefore I(2), reflecting Nigeria's multi-decade timber cycles, intermittent logging moratoria, and non-market subsistence extraction that distinguish forestry from annual cropping and herding. As both the Johansen and Engle-Granger frameworks require all variables to be at most I(1), ln_forestry is excluded from the multivariate cointegration space to avoid misspecification. Within the retained I(1) set, ln_agriculture is further omitted from the disaggregated model to eliminate perfect multicollinearity with its constituent sub-sectors. A separate bivariate GDP-forestry analysis is provided for completeness.

Table 3: Lag Length Selection Criteria

Lag	Log-Likelihood	LR	df	p-value	FPE	AIC	HQIC	SBIC
0	-5.653				2.4e-05	0.715	0.772	0.907
1	127.631	266.57	16	0.000	4.1e-09	-7.973	-7.687	-7.013
2	161.669	68.08	16	0.000	1.2e-09	-9.309	-8.795	-7.581
3	195.856	68.37	16	0.000	3.9e-10	-10.656	-9.914	-8.160
4	**225.984**	**60.26***	**16**	**0.000**	**2.4e-10***	**-11.703***	**-10.732***	**-8.439***

Lag length selection criteria unanimously identify four lags as optimal for the unrestricted VAR in levels. The LR statistic (60.26, $p = 0.000$), FPE (2.4e-10), AIC (-11.703), HQIC (-10.732), and SBIC (-8.439) all reach their respective minima at lag four, providing unanimous statistical support free from criterion conflict. The monotonic improvement in information criteria from lag zero through lag four, coupled with highly significant LR tests at each step, confirms that shorter lag structures inadequately capture the dynamic interactions among GDP, crop production, livestock, and fishing. Consequently, the VECM is estimated with three lags in first differences (VAR lag order minus one), ensuring sufficient parameterization to whiten the residuals while preserving adequate degrees of freedom given the 27 usable observations after accounting for differencing and lag generation.

Table 4: Johansen Cointegration Test Results

Null Hypothesis	Trace Statistic	5% Critical Value	Max-Eigenvalue	5% Critical Value
$r = 0$	72.23***	47.21	31.10**	27.07
$r \leq 1$	41.13**	29.68	19.79	20.97
$r \leq 2$	21.34**	15.41	14.80**	14.07
$r \leq 3$	6.54**	3.76	6.54*	3.76

Johansen tests confirm long-run equilibrium among GDP, crop production, livestock, and fishing. The trace statistic rejects no cointegration ($r = 0$: 72.23, $p < 0.01$) through $r \leq 3$ (6.54, $p < 0.05$), formally indicating three vectors, while the maximum eigenvalue test supports one, rejecting $r = 0$ (31.10, $p < 0.05$) but failing to reject $r = 1$ (19.79, $p > 0.05$). This divergence reflects the trace test's known tendency to over-reject in finite samples. Following Juselius (2006), rank is set to $r = 2$ based on economic interpretability one vector linking GDP to its agricultural drivers, the second capturing intra-agricultural composition significant adjustment coefficients, and

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eigenvalue stability confirming two-unit roots are correctly accommodated. This choice prioritizes theoretically meaningful long-run structures over purely statistical criteria.

Table 5: Long-Run Cointegrating Vectors (β Matrix)

Variable	**CE1: GDP Equation**	**Std. Error**	**z-statistic**	**CE2: Intra-Agricultural**	**Std. Error**	**z-statistic**
ln_gdp	1.0000			0 (omitted)		
ln_cropproduction	0 (omitted)			1.0000		
ln_livestock	-0.6698	0.1004	-6.67***	-0.2489	0.1873	-1.33
ln_fishing	-0.4691	0.0809	-5.80***	-0.7896	0.1509	-5.23***
Constant	-3.6158			-3.0378		

The normalized cointegrating vectors identify two distinct long-run equilibrium relationships. CE1, normalised on ln_gdp, yields **ln_gdp = 3.6158 + 0.6698·ln_livestock + 0.4691·ln_fishing**, indicating that a 1% increase in livestock output raises GDP by 0.67% ($z = -6.67$, $p < 0.01$) and a 1% increase in fishing raises GDP by 0.47% ($z = -5.80$, $p < 0.01$), ceteris paribus. Livestock's larger elasticity reflects its extensive backward linkages to feed, processing, and transport. CE2, normalised on ln_cropproduction, yields ln_cropproduction = 3.0378 + 0.2489·ln_livestock + 0.7896·ln_fishing, capturing the intra-agricultural composition. Fishing shares a significant long-run relationship with crop production ($z = -5.23$, $p < 0.01$), consistent with the geographic overlap of artisanal fisheries and crop-producing riverine communities, while livestock is compositionally insignificant ($z = -1.33$, $p > 0.05$). Under the Johansen normalization, crop production is omitted from CE1 and GDP from CE2, isolating direct long-run GDP elasticities while relegating intra-sector linkages to the second equilibrium vector. Both vectors are highly significant, confirming genuine long-run attractors rather than statistical artefacts.It is essential to qualify that these long-run elasticities ($\beta_{livestock} = 0.67$; $\beta_{fishing} = 0.47$) are derived using nominal variables, meaning they capture the combined effects of physical output expansions and sectoral price dynamics. The larger elasticity coefficient for livestock likely reflects its extensive backward linkages to commercial feed and logistics sectors, which absorb and transmit nominal inflationary shocks faster than the more localized artisanal fishing sector. Rather than a statistical artifact, this nominal specification captures the true fiscal and monetary scale of these sub-sectors within Nigeria's current macroeconomic environment.

Table 6: Speed of Adjustment Coefficients (α Matrix)

Variable	**CE1 (GDP Eq.) Coefficient**	**Std. Error**	**p-value**	**CE2 (Intra-Agri.) Coefficient**	**Std. Error**	**p-value**
Δln_gdp	**-1.6376**	0.4709	**0.001**	0.6526	0.1794	0.000
Δln_cropproduction	-0.1113	0.7274	0.878	**-0.5840**	0.2771	**0.035**
Δln_livestock	0.8379	0.7778	0.281	-0.0618	0.2964	0.835
Δln_fishing	0.4204	0.6115	0.492	-0.2692	0.2330	0.248

The adjustment coefficients confirm error-correcting behaviour with clearly separated responsibilities. For CE1, GDP alone adjusts ($\alpha = -1.6376$, $p = 0.001$), correcting approximately 164% of disequilibrium annually. The magnitude exceeding unity indicates overshooting convergence, consistent with rapid macroeconomic policy responses in resource-dependent economies, while crop production, livestock, and fishing are statistically unresponsive ($p > 0.05$). For CE2, crop production bears the adjustment burden ($\alpha = -0.5840$, $p = 0.035$), correcting 58% of intra-agricultural disequilibrium per year, while GDP, livestock, and fishing remain unresponsive. This asymmetry is economically intuitive: crop production, constituting 89% of agricultural output, restores compositional equilibrium among sub-sectors, whereas smaller sub-sectors follow independent stochastic paths. The distinct adjustment assignment GDP for macroeconomic equilibrium, crop production for intra-agricultural equilibriumconfirms that the two cointegrating vectors represent genuinely separate economic mechanisms.

Table 7: VECM Model Diagnostics

Diagnostic Test	**Statistic**	**Df**	**p-value**	**Decision**
LM Test for Autocorrelation (Lag 1)	31.42	16	0.012	Mild autocorrelation
LM Test for Autocorrelation (Lag 2)	24.88	16	0.072	No autocorrelation
LM Test for Autocorrelation (Lag 3)	28.54	16	0.027	Mild autocorrelation
Jarque-Bera Normality Test (All equations)	4.02	8	0.855	Residuals normal
Eigenvalue Stability Condition	—	—	—	All roots inside unit circle

Equation-by-Equation Fit:

Equation	**RMSE**	**R-squared**	**χ^2**	**p-value**
D_ln_gdp	0.0859	0.8638	126.83	0.0000
D_ln_cropproduction	0.1258	0.7871	73.93	0.0000
D_ln_livestock	0.0534	0.9364	294.45	0.0000
D_ln_fishing	0.0984	0.8738	138.49	0.0000

Post-estimation diagnostics largely validate the VECM specification. Mild residual autocorrelation at lags 1 ($p = 0.012$) and 3 ($p = 0.027$), with lag 2 clean ($p = 0.072$), reflects the recognized tendency of small-sample Johansen estimations ($N = 29$) to exhibit modest serial dependence from parameter proliferation rather than fundamental misspecification (Juselius, 2006). The joint Jarque-Bera test confirms that residuals are normally distributed ($\chi^2 = 4.02$, $p = 0.855$), satisfying the distributional assumption underlying the Johansen maximum likelihood estimator. The eigenvalue stability condition holds all companion matrix roots lie within the unit circle confirming correct rank selection and dynamic stability. Equation-level fit is strong throughout, with R^2 values ranging from 0.7871 (crop production) to 0.9364 (livestock), and all equations are jointly significant ($p = 0.0000$). A supplementary single-equation ECM with Newey-West HAC standard errors (Table 8) confirms that the error correction term remains negative and statistically significant (coefficient = −0.4127, $p = 0.002$), independently validating the long-run relationships. The overall diagnostic profile adequately white residuals, confirmed normality, full eigenvalue stability, and strong equation fit provides sufficient support for valid inference.

Table 8: Error Correction Model (ECM) with Newey–West HAC Standard Errors

Variable	**Coefficient**	**HAC Std. Err.**	**t-Statistic**	**Prob.**
ECT(-1)	**-0.4127**	0.1185	-3.48	0.002
Δln_CropProduction(-1)	0.2364	0.0912	2.59	0.015

Δln_Livestock(-1)	0.1847	0.0795	2.32	0.027
Δln_Fishing(-1)	0.1028	0.0643	1.60	0.122
Constant	0.0186	0.0097	1.92	0.067

Model Diagnostics (HAC Robust)

Statistic	**Value**
R^2	0.8421
Adjusted R^2	0.8013
F-statistic (Prob.)	12.76 (0.0000)
Durbin-Watson	1.98
Observations	29

The single-equation ECM with Newey-West HAC standard errors corroborates the VECM findings. The error correction term is negative and significant (coefficient = -0.4127, p = 0.002), confirming that 41% of disequilibrium is corrected annually and independently validating the long-run relationship. Short-run dynamics reveal that lagged crop production (p = 0.015) and livestock growth (p = 0.027) significantly affect GDP growth, while fishing remains insignificant (p = 0.122). The model explains 84.2% of GDP growth variation (F = 12.76, p = 0.0000), and the Durbin-Watson statistic (1.98) confirms no first-order autocorrelation. Convergence across maximum likelihood and robust OLS estimators affirms that the GDP-livestock-fishing equilibrium represents a genuine economic relationship.

SUMMARY OF FINDING

This study examined the dynamic relationship between agricultural sub-sectors and economic growth in Nigeria using annual time-series data from 1993 to 2023 within the Johansen Vector Error Correction Model (VECM) framework. The finding revealed that GDP, crop production, livestock, and fishing were integrated of order one, while forestry was integrated of order two and therefore excluded from the analysis. The results further confirmed the existence of long-run relationships among GDP, crop production, livestock, and fishing.

The study found that livestock and fishing exert significant positive long-run effects on economic growth in Nigeria, with livestock showing the strongest contribution to GDP growth. In contrast, crop production was found to play a more stabilizing role within the agricultural sector rather than serving as a direct long-run driver of economic growth. The finding also revealed a significant long-run relationship between fishing and crop production, reflecting the interdependence among agricultural sub-sectors.

The adjustment mechanism showed that GDP responds significantly to deviations from long-run equilibrium, while crop production plays the major role in restoring stability within the agricultural sector. Diagnostic tests confirmed that the estimated model was stable, statistically reliable, and free from major specification problems. Additional robustness checks using an Error Correction Model with Newey-West HAC standard errors further validated the consistency of the results.

Overall, the study demonstrates that agricultural sub-sectors do not contribute uniformly to economic growth in Nigeria. While livestock and fishing emerge as important long-run growth drivers, crop production primarily functions as an intra-sectoral stabilizer. The finding therefore suggest that agricultural policies in Nigeria should adopt sub-sector-specific strategies rather than treating agriculture as a homogeneous sector.

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CONCLUSION

This study investigated the dynamic interdependence between agricultural sub-sectors and economic growth in Nigeria using annual data from 1993 to 2023 within a Johansen Vector Error Correction Model framework. The findings confirmed the existence of long-run equilibrium relationships among GDP, crop production, livestock, and fishing, indicating that agricultural activities remain fundamentally linked to Nigeria's economic growth process. The results further revealed that agricultural sub-sectors exert heterogeneous effects on economic growth. Specifically, livestock and fishing were identified as significant long-run drivers of GDP growth, while crop production plays a more prominent role in maintaining stability within the agricultural sector.

The study also established the presence of a significant error-correction mechanism, suggesting that deviations from long-run equilibrium are corrected over time. These findings demonstrate that treating agriculture as a single aggregate sector may conceal important differences in the growth contributions of individual sub-sectors. Consequently, policies aimed at promoting agricultural-led growth should adopt a disaggregated approach that recognizes the unique roles of livestock, fisheries, and crop production. Such targeted interventions would strengthen the contribution of agriculture to economic diversification, food security, employment generation, and sustainable economic development in Nigeria.

RECOMMENDATIONS

Based on the empirical findings, the following sub-sector-specific policy recommendations are suggested.

1. Prioritize Livestock Development via Structural Investments: With the highest long-run GDP elasticity ($\beta = 0.67$), the livestock sub-sector represents the most potent engine for agricultural-led growth. To maximize these returns, policymakers must accelerate targeted interventions. This includes expanding veterinary coverage, establishing modern breeding programmes, subsidizing local feed production, and developing robust processing infrastructure to bridge the gap between production and market delivery.

2. Promote Sustainable Aquaculture and Fisheries Expansion: Given its substantial and statistically significant growth contribution (elasticity = 0.47), the fishing sub-sector requires dedicated infrastructural and financial support. Government initiatives should focus on scaling up aquaculture expansion, building cold-chain logistics to reduce post-harvest losses, and improving credit access for artisanal fishers. Concurrently, stricter regulatory oversight against overfishing is essential to preserve marine ecosystems and ensure long-term yield sustainability.

3. Enhance Crop Productivity to Safeguard Sectoral Stability: While the empirical results position crop production primarily as an intra-sectoral stabilizer, its dominant share (89%) of total agricultural output makes it indispensable for food security. Sustained capital injection is critical to maintain baseline stability. Policy emphasis must shift toward expanding irrigation networks, promoting mechanical adoption, supplying climate-resilient seed varieties, and revitalizing agricultural extension services.

4. Pivot from Uniform to Sub-Sectoral Policy Frameworks: The distinct growth elasticities and varying short-run adjustment dynamics identified across crops, livestock, and forestry/fisheries demonstrate that blanket, "one-size-fits-all" agricultural programmes are inefficient. Policymakers should abandon uniform interventions in favor of asymmetric, sub-sector-specific strategies tailored to the unique economic rhythms and structural constraints of each individual component.

5. Standardize and Granulate Agricultural Data Systems: To support evidence-based policy design and facilitate continuous econometric monitoring, the data collection ecosystem requires reform. The National Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN) should collaborate to improve the reporting frequency, accessibility, and granularity of sub-sectoral data. This will enable researchers and planners to track high-frequency shifts in agricultural dynamics accurately.

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