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AGRICULTURAL OUTPUT AND POVERTY IN NIGERIA: EVIDENCE FROM THE TODA–YAMAMOTO CAUSALITY APPROACH

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Abstract *Despite agriculture contributing about one-quarter of Nigeria's Gross Domestic Product (GDP) and employing more than one-third of the labour force, multidimensional poverty remains pervasive. Using annual data for 1982–2024 (43 observations), this study examines the causal relationship between agricultural output and poverty in Nigeria, with the Human Development Index (HDI) serving as a multidimensional proxy for poverty. The Toda–Yamamoto causality framework is employed because of its robustness to the integration and cointegration properties of time-series variables. thereby avoiding the pre-test bias associated with conventional Granger causality analysis.The empirical findings reveal a bidirectional causal relationship between agricultural output and HDI, suggesting that improvements in agricultural production enhance human development through increased food availability, employment, and rural incomes, while improvements in education, health, and living standards simultaneously strengthen agricultural productivity. This feedback mechanism underscores the complementary and interdependent nature of agricultural performance and poverty reduction in Nigeria. The study concludes that agricultural development and poverty reduction are mutually reinforcing and recommends an integrated policy framework that simultaneously promotes agricultural productivity, human capital development, rural employment, and improved access to agricultural*

finance to achieve sustainable poverty reduction in Nigeria.

Keywords Agricultural Output, Poverty, Multidimensional Poverty, Human Development Index, Toda-Yamamoto Causality

JEL Classification code: O13, O15, O47, Q10, C32

1. Introduction

Agriculture remains a critical driver of economic growth and poverty reduction in developing countries, particularly in sub-Saharan Africa. In Nigeria, the sector contributes approximately 25% of Gross Domestic Product (GDP), employs over one-third of the labour force, supports food security, supplies raw materials to industries, and generates rural livelihoods (National Bureau of Statistics [NBS], 2023; World Bank, 2023). Consequently, agricultural development is widely regarded as a fundamental pathway for achieving inclusive growth and improving household welfare.

The poverty-reducing potential of agriculture has been extensively acknowledged in both theoretical and empirical literature. Growth in agricultural output improves food availability, raises rural incomes, creates employment opportunities, and stimulates economic activities through production and consumption linkages. Empirical studies have shown that improvements in agricultural productivity significantly enhance human welfare and contribute to long-run poverty reduction in Nigeria (Umar et al., 2023; Adeoye, 2024; Ogunjobi et al., 2024). Similarly, the World Bank (2023) reports that agricultural growth is considerably more effective in raising the incomes of poor households than growth originating from many other sectors.

Despite these contributions, poverty remains widespread in Nigeria. According to the United Nations Development Programme (UNDP, 2023/2024), Nigeria recorded a Human Development Index (HDI) of 0.548, ranking among countries with low human development. This persistent poverty, despite the substantial contribution of agriculture to national output, raises important questions regarding whether increases in agricultural output translate into measurable improvements in human welfare.

The relationship between agricultural output and poverty is influenced by broader macroeconomic conditions. Real Gross Domestic Product (RGDP) reflects overall economic performance and may strengthen the welfare effects of agricultural growth through higher income and employment. Labour Force Participation Rate (LFPRT) captures the productive engagement of the working-age population and represents an important channel through which agricultural expansion improves household welfare. Likewise, access to agricultural finance through the Agricultural Credit Guarantee Scheme Fund (ACGSF) enables farmers to adopt improved technologies and increase productivity, thereby enhancing agricultural output and rural incomes (CBN, 2022).

Although successive governments have implemented several agricultural development programmes, including the Agricultural Transformation Agenda, the Agricultural Promotion Policy, and the Anchor Borrowers' Programme, poverty levels remain persistently high. This raises an important policy question: does agricultural output actually cause improvements in human development, or does improved human development itself stimulate agricultural production? Existing Nigerian studies have largely concentrated on long-run relationships using Autoregressive Distributed Lag (ARDL) models, while relatively few have rigorously investigated the direction of causality. Moreover, conventional Granger causality procedures are sensitive to unit-root and cointegration properties and may produce biased inference when pre-testing errors occur (Toda & Yamamoto, 1995).

This study addresses these gaps by employing the Toda–Yamamoto causality framework to examine the causal relationship between agricultural output and multidimensional poverty in Nigeria over the period 1982–2024. Unlike previous studies that primarily relied on income-based poverty indicators, this study adopts the Human Development Index as a broader measure of human welfare. The analysis also incorporates Real Gross Domestic Product, Labour Force Participation Rate, and the Agricultural Credit Guarantee Scheme Fund as control variables to capture the macroeconomic and institutional factors influencing the agriculture–poverty nexus. The findings are expected to provide more robust evidence for designing policies that simultaneously promote agricultural growth and sustainable poverty reduction.The rest of the paper is structured as follows: Section 2 reviews the relevant literature; Section 3 presents the methodology; Section 4 discusses the findings; while Section 5 concludes the paper.

2. Literature Review

2.1 Conceptual Review

Agricultural output refers to the total quantity or value of agricultural goods produced within an economy over a specified period, including crop production, livestock, fisheries, and forestry. It reflects the productive performance of the agricultural sector and its contribution to national income, food security, employment, and industrial development (Ewetan et al., 2017; Ojima, 2024).

Poverty extends beyond inadequate income to encompass deprivations in health, education, nutrition, and living standards. Sen (1999) conceptualizes poverty as capability deprivation, emphasizing individuals' inability to achieve acceptable levels of well-being rather than merely insufficient income. This multidimensional perspective has gained broad acceptance in development literature (Todaro & Smith, 2020; Fragoso, 2025).

Consistent with this perspective, this study adopts the Human Development Index (HDI) as a proxy for poverty. Although HDI is not a direct poverty measure, it captures three fundamental dimensions of human well-being, health, education, and standard of living and therefore provides a broader assessment of welfare than conventional income-based indicators (UNDP, 2024; UNDP, 2025).

2.2 Theoretical Framework

This study is anchored on Mellor's (1976) Agriculture-Led Growth Model, which explains how agricultural growth stimulates poverty reduction through income generation, employment creation, and strong production and consumption linkages. The model argues that broad-based agricultural expansion, particularly among smallholder farmers, raises household incomes, stimulates demand for rural non-farm activities, and accelerates overall economic transformation.

The model is particularly relevant to Nigeria because agriculture remains the largest employer of labour and a major source of rural livelihoods. It provides a clear theoretical explanation of how improvements in agricultural output can reduce multidimensional poverty through increased food availability, higher incomes, employment opportunities, and broader economic linkages. Conversely, where agricultural growth fails to reduce poverty, the model attributes the outcome to weak market integration, inadequate infrastructure, poor access to finance, and unequal distribution of productive resources. Consequently, the Agriculture-Led Growth Model provides an appropriate framework for analysing the causal relationship between agricultural output and human development in Nigeria.

2.3 Empirical Review

Recent empirical studies have examined the relationship between agricultural output and poverty reduction using different econometric techniques and welfare indicators.

Adeoye (2024) examined the relationship between agricultural productivity and poverty reduction in Nigeria between 1980 and 2021 using the Autoregressive Distributed Lag (ARDL) model. Findings revealed that agricultural productivity, particularly in crops, fisheries, and forestry, exerts a positive and statistically significant influence on the Human Development Index (HDI), suggesting that improvements in agricultural output contribute to enhanced welfare and poverty reduction. In a related study, Ogunjobi et al. (2024) investigated the relationship between agricultural productivity and poverty alleviation in Nigeria using the ARDL technique alongside the Granger causality test. The results confirmed the existence of a long-run relationship between agricultural productivity and HDI. The causality analysis further revealed a bidirectional causal relationship between agricultural GDP and HDI, indicating mutual interaction between agricultural productivity and poverty reduction.

Owonda (2024) assessed the effect of agricultural investment on poverty reduction using the Autoregressive Distributed Lag framework with data spanning the period between 1989-2019. The findings showed that agricultural investment significantly contributes to poverty reduction in both the short run and the long run, highlighting the importance of sustained investment in agricultural development. Beside, Bertrand (2023) examined sectorial contributions to poverty reduction in selected Sub-Saharan African countries using panel econometric techniques. The findings indicated that agricultural value added exerts a stronger and statistically significant impact on poverty reduction when compared with

other sectors of the economy, underscoring the importance of agriculture in improving welfare outcomes. However, study by Umar et al. (2023) who investigated the relationship between agricultural output and poverty reduction through the ARDL bounds testing technique revealed that growth in agricultural output significantly increases per capita income, which consequently contributes to long-run poverty reduction in Nigeria.

Tochukwu et al. (2022) examined the nexus among agriculture, food security, and poverty reduction in Nigeria using cointegration and Granger causality techniques with data covering 1990 to 2019. The findings revealed the existence of a long-run equilibrium relationship among agricultural value added, food production index, and GDP per capita. The causality analysis further indicated a unidirectional causal relationship running from food production to poverty reduction, as well as another causal link from poverty reduction to agricultural value added.

In another causality-based study, Omoyele et al. (2022) examined the relationship among economic growth, unemployment, and poverty in Nigeria using Granger causality analysis with time series data spanning the period between 1990 - 2019. The findings showed no causal relationship between economic growth and poverty reduction, although a unidirectional causality running from poverty to youth unemployment was identified.

Demehin and Ushie (2021) investigated the effect of agricultural growth on poverty reduction in Nigeria using the Autoregressive Distributed Lag technique with data covering the period between1986 - 2020. The findings revealed that agricultural productivity, deposit money banks' credit to agriculture, and federal government budgetary allocations significantly reduce poverty incidence. The causality analysis further indicated a unidirectional causal relationship running from agricultural productivity to poverty incidence, implying that improvements in agricultural output can stimulate poverty reduction. However, Kelikume and Nwani (2020) investigated the causal relationship between agricultural sector output and economic growth in Nigeria using Vector Autoregression and Granger causality techniques with annual data covering the period between 1981 - 2018. The results revealed a unidirectional causal relationship running from economic growth to agricultural output, indicating that agricultural sector performance may be influenced by broader macroeconomic conditions.

2.4 Literature Gap

Despite extensive empirical investigations, several gaps remain in the literature. First, existing findings on the causal relationship between agricultural output and poverty reduction remain inconsistent, with studies reporting bidirectional, unidirectional, and insignificant causal relationships. Second, most Nigerian studies have relied on income-based measures such as poverty incidence and per capita income, which do not adequately capture the multidimensional nature of poverty. Although Ogunjobi et al. (2024) also employed the Human Development Index (HDI) and reported a bidirectional relationship between agricultural productivity and human

development, their analysis was based on the ARDL and conventional Granger causality framework. This study extends the literature by employing the more robust Toda–Yamamoto causality approach, which is valid irrespective of the integration and cointegration properties of the variables and avoids pre-test bias(Toda & Yamamoto, 1995; Zapata & Rambaldi, 1997).

Furthermore, the study utilizes a longer and more up-to-date dataset covering 1982–2024 and incorporates Real Gross Domestic Product (RGDP), Labour Force Participation Rate (LFPRT), and the Agricultural Credit Guarantee Scheme Fund (ACGSF) as additional macroeconomic and institutional variables to provide a more comprehensive understanding of the agriculture–poverty nexus in Nigeria.

3. Methodology

This study examined the causal relationship between agricultural output and poverty in Nigeria based on human development index from 1982-2024.

3.1 Data Source and Measurement of variables

This study utilized secondary annual time series data. The variables on which data were obtained from Central Bank of Nigeria Statistical Bulletin (CBN, 2024) are agricultural output (AGOUT), real gross domestic product (RGDP) and agricultural credit guarantee scheme fund (ACGSF), while the other two variables;labour force participation rate (LFPRT) and human development index (HDI) were obtained from World Development Indicators (WDI, 2024) and United Nations Development Programme Human Development Reports (UNDP HDR, 2023/24). AGOUT is measured as Agriculture value added/Contribution to GDP ($ billion), ACGSF is measured as aggregate monetary value of loans granted in the agricultural sector ($ billion), RGDP is measured at Constant price GDP ($ billion), LFPRT is measured as percentage of economically active population, and HDI is measured in annual Human Development Index value ranging between 0 and 1.

3.2 Model specification

To examine the direction of causality between agricultural output and poverty, this study adopts the Toda–Yamamoto (1995) causality approach. The technique is preferred to the conventional Granger causality procedure because it remains valid irrespective of whether the variables are integrated of order I(0), I(1), or I(2), and regardless of the existence of cointegration. Consequently, it eliminates the pre-test bias associated with traditional causality analysis and provides more reliable statistical inference (Toda & Yamamoto, 1995; Zapata & Rambaldi, 1997).

The functional relationship is specified as:

$$HDI=f(AGOUT, RGDP, LFPRT, ACGSF) \quad 1$$

Where, HDI = Human Development Index (represent multidimensional poverty indicators), AGOUT = Agricultural Output, RGDP = Real Gross Domestic Product, LFPRT = Labour force participation rate,

ACGSF = Agricultural credit guarantee scheme fund.

To isolate the causal effect of agricultural output on poverty, this study incorporates Real Gross Domestic Product (RGDP), Labour Force Participation Rate (LFPRT), and the Agricultural Credit Guarantee Scheme Fund (ACGSF) as control variables. RGDP is included because economic growth influences welfare outcomes through employment and income generation (Kuznets, 1955). LFPRT is controlled for as labour participation is a primary channel translating economic activities into improved living standards (World Bank, 2018). ACGSF is included because access to agricultural finance determines productivity and rural welfare (Diagne et al., 2000). The inclusion of these variables follows standard practice to avoid omitted variable bias and ensure robust causal estimates (Gujarati & Porter, 2009).

The variables in this study are measured in different units and magnitudes. Specifically, AGOUT and RGDP are measured in billions of Naira (₦),ACGSF is measured in millions of Naira (₦), while LFPRT is measured as a percentage (%). To address this scale disparity, the study normalize the data, and stabilize the variance of the series, the natural logarithm transformation is applied to AGOUT, RGDP, and ACGSF. The log-linear transformation converts exponential growth patterns into linear relationships and allows the estimated coefficients to be interpreted as elasticities (Gujarati , 2012). However, LFPRT is retained in its level form because it is already a rate (percentage) and does not suffer from the same scale incompatibility. Furthermore, applying a log transformation to a ratio variable complicates the interpretation of the marginal effects without providing additional statistical benefits (Wooldridge, 2016).

In line with the Toda–Yamamoto approach, the augmented Vector Autoregression (VAR) model is estimated with an optimal lag length k and a maximum order of integration d_{max}. The Toda-Yamamoto VAR ($k + d_{max}$) system in levels can be written as:

$$HDIt = \propto 0 + \sum_{i=1}^{k+dma} \beta i HDIt - 1 + \sum_{i=1}^{k+dm} \lambda i AGOUTt - 1 + \sum_{i=1}^{k+dmax} \delta i RGDPt - I + \sum_{i=1}^{k+dmax} \alpha i\, LFPRt - 1 + \sum_{i=1}^{k+dmax} \theta i ACGSFt - I + \epsilon t \qquad 2$$

$$AGOUTt = \lambda 0 + \sum_{i=1}^{k+dmax} \mu i AGOUTt-1 + \sum_{i=1}^{k+dmax} \rho i HDIt-1 + \sum_{i=1}^{k+dma} \alpha j RGDPt-1 + \sum_{i=1}^{k+dma} \alpha i\ LFPRt-1 + \sum_{i=1}^{k+dmax} \phi j ACGSFt-1 + \mu t \quad 3$$

$$RGDPt = \lambda 0 + \sum_{i=1}^{k+dm} \alpha j RGDPt-1 + \sum_{i=1}^{k+dm} \rho i HDIt-1 + \sum_{i=1}^{k+dma} \lambda i AGOUTt-1 + \sum_{i=1}^{k+dm} \alpha i\ LFPRt-1 + \sum_{i=1}^{k+dm} \phi j ACGSFt-1 + \mu t \quad 4$$

$$LFPRt = \lambda 0 + \sum_{i=1}^{k+dm} \alpha i\ LFPRt-1 + \sum_{i=1}^{k+dma} \rho i HDIt-1 + \sum_{i=1}^{k+dmax} \lambda i AGOUTt-1 + \sum_{i=1}^{k+dm} \alpha j RGDPt-1 + \sum_{i=1}^{k+dmax} \phi j ACGSFt-1 + \mu t \quad 5$$

$$ACGSFt = \lambda 0 + \sum_{i=1}^{k+dmax} \phi j ACGSFt-1 + \sum_{i=1}^{k+dmax} \rho i HDIt-1 + \sum_{i=1}^{k+dmax} \lambda i AGOUTt-1 + \sum_{i=1}^{k+dmax} \alpha j RGDPt-1 + \sum_{i=1}^{k+dmax} \alpha i\ LFPRt-1 + \mu t \quad 6$$

Where k is the optimal lag length selected via the Akaike Information Criterion (AIC), $d_{max}$is the maximum order of integration among the variables, and εt, ut, ut, ϵt represent the white noise error terms.

The direction of causality among the variables is determined using the Modified

Wald (MWALD) test on the coefficients of the first k lagged variables in the augmented VAR system. The extra d_{max} lags are included in the system but are restricted from the causality test to ensure the MWALD statistic follows an asymptotic $\chi 2$ distribution. The rejection of the null hypothesis of no Granger causality indicates the presence of a predictive causal relationship among the variables

4. Discussion of Results

4.1 Pre-estimation Result

Prior to estimating the Toda–Yamamoto causality model, the stationarity properties of the variables were examined using the Augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests.

Table 1: *Result of the ADF and KPSS Unit Root Test*

Variables	ADF Level	KPSS Level	ADF 1st Diff.	KPSS 1st Diff.	Order of Integration
HDI	0.872(-2.933)	0.809(0.463)	-7.170(-2.935)***	0.295(0.463)***	I (1)
lnAGOUT	-0.742(-2.933)	0.807(0.463)	-6.086(-2.935)***	0.173(0.463)***	I (1)
lnRGDP	-0.928(-2.935)	0.797(0.463)	-5.300(-2.935)***	0.188(0.463)***	I (1)
LFPART	-1.037(-2.951)	0.515(0.463)	-4.938(-2.954)***	0.299(0.463)***	I (1)
lnACGSF	-1.286(-2.933)	0.753(0.463)	-5.879(-2.935)***	0.191(0.463)***	I (1)

***Note*: ***/**/* indicates statistically significant at 1%, 5%, and 10% respectively**
Source: Computation Output Using E-views 10, 2026

Table 1 shows the results of augmented Dickey-Fuller (ADF) and Kwiatkowski–Philips-Schmidt-Shin (KPSS) unit root tests of stationarity. The KPSS unit root test is performed as a confirmatory test to ascertain the highest order of integration. The ADF and KPSS results consistently indicate that all variables become stationary after first differencing, implying that they are integrated of order one, I(1). The consistency of both tests confirms the maximum order of integration (dmax = 1), thereby satisfying one of the major requirements for implementing the Toda–Yamamoto causality procedure.

Table 2: Lag Length Criteria for F-Bound Test

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	88.72968	NA	3.10e-09	-5.401915	-5.170627	-5.326521
1	250.7439	261.3133	4.61e-13	-14.24154	-12.85381	-13.78918
2	308.4283	74.43153*	6.41e-14	-16.35022	-13.80605	-15.52088
3	347.1574	37.47977	3.90e-14	-17.23596	-13.53535	-16.02966

4	398.1721	32.91266	1.82e-14*	-18.91433*	-14.05727*	-17.33105*

Source: Computation Output Using E-views 10, 2026

The optimal lag length presented in Table 2 was determined using the Akaike Information Criterion (AIC), Schwarz Criterion (SC), Hannan–Quinn Criterion (HQ), Final Prediction Error (FPE), and the Sequential Likelihood Ratio (LR) test. Although the LR criterion selected two lags, most information criteria identified four lags as optimal. Accordingly, a lag length of four was adopted because it provides a better representation of the dynamic interactions among the variables while minimizing model misspecification.

4.2 Result of Toda-Yamamoto Causality Test

Table 3L: Toda-Yamamoto causality test

Null Hypothesis	Chi-Sq	Prob.	Decision	Direction of Causality
lnAGOUT does not cause HDI	106.4878	0.0000	Rejected	lnAGOUT → HDI
lnRGDP does not cause HDI	31.15776	0.0000	Rejected	lnRGDP → HDI
LFPRT does not cause HDI	99.20719	0.0000	Rejected	LFPRT → HDI
lnACGSF does not cause HDI	45.16126	0.0000	Rejected	lnACGSF → HDI
HDI does not cause lnAGOUT	12.94494	0.0115	Rejected	HDI → lnAGOUT
lnRGDP does not cause lnAGOUT	6.988381	0.1365	Not Rejected	No Causality
LFPRT does not cause lnAGOUT	10.10084	0.0388	Rejected	LFPRT→ lnAGOUT
lnACGSF does not cause lnAGOUT	12.84869	0.0120	Rejected	lnACGSF→ lnAGOUT
HDI does not cause lnRGDP	22.60051	0.0002	Rejected	HDI→ lnRGDP
lnAGOUT does not cause lnRGDP	14.43714	0.0060	Rejected	lnAGOUT→ lnRGDP
LFPRT does not cause lnRGDP	23.98753	0.0001	Rejected	LFPRT→ lnRGDP
lnACGSF does not cause lnRGDP	35.79908	0.0000	Rejected	lnACGSF→ lnRGDP
HDIdoes not cause LFPRT	5.958235	0.2023	Not Rejected	No Causality
lnAGOUT does not cause LFPRT	5.578257	0.2329	Not Rejected	No Causality
lnRGDP does not cause LFPRT	1.133569	0.8889	Not Rejected	No Causality
lnACGSF does not cause LFPRT	9.261389	0.0549	Not Rejected	No Causality
HDI does not cause lnACGSF	4.936565	0.2939	Not Rejected	No Causality

Null Hypothesis	Chi-Sq	Prob.	Decision	Direction of Causality
lnAGOUT does not cause lnACGSF	6.993333	0.1362	Not Rejected	No Causality
lnRGDP does not cause lnACGSF	6.826750	0.1453	Not Rejected	No Causality
LFPRT does not cause lnACGSF	3.316646	0.5063	Not Rejected	No Causality

Remarks: Variables with Bidirectional Relationship; lnAGOUT↔HDI, lnRGDP↔HDI. **Variables with Unidirectional Relationship;** LFPRT→HDI, lnACGSF → HDI,LFPRT→ lnAGOUT, lnACGSF→ lnAGOUT, lnAGOUT→ lnRGDP, LFPRT→ lnRGDP, lnACGSF→ lnRGDP.
Source: Computation Output Using E-views 10, 2026

Table 3 reports the results of the Toda–Yamamoto causality test conducted to determine the direction of causal relationships among agricultural output (lnAGOUT), human development index (HDI), real gross domestic product (lnRGDP), labour force participation (LFPRT), and the Agricultural Credit Guarantee Scheme Fund (lnACGSF) in Nigeria.

The analysis also reveals a bidirectional causal relationship between lnAGOUT and HDI. The null hypothesis that lnAGOUT does not cause HDI was rejected (χ^2 = 1069.879, $p < 0.01$), while the hypothesis that HDI does not cause lnAGOUT was equally rejected (χ^2 = 12.94494, p = 0.0115). This indicates that agricultural output and human development reinforce one another over time through a clear feedback mechanism. Specifically, higher agricultural output (AGOUT ↑) increases food availability, rural household income, and employment opportunities, which improve living standards and ultimately enhance human development (HDI ↑). In turn, improvements in HDI, reflected in better health, education, and living standards, strengthen labour productivity, farmers' technical capacity, and the adoption of improved agricultural technologies, thereby raising agricultural output (AGOUT ↑). Thus, the causal relationship operates through the transmission channel: AGOUT ↑ → Food availability, Income and Employment ↑ → HDI ↑ → Better Health, Education and Skills ↑ → Higher Productivity ↑ → AGOUT ↑. This finding supports Ogunjobi et al. (2024), who also reported a bidirectional causal relationship between agricultural productivity and human development in Nigeria. However, it contrasts with the unidirectional causal relationships reported by Demehin and Ushie (2021) and Tochukwu et al. (2022).

The findings also reveal a bidirectional causal relationship between lnRGDP and HDI. Specifically, lnRGDP significantly influences HDI (χ^2 = 31.15776, $p < 0.01$), while HDI also significantly influences lnRGDP (χ^2 = 22.60051, $p < 0.01$), indicating that economic growth and human development are mutually reinforcing. Economic growth improves welfare through higher incomes, employment, and public investment in health and education, while improvements in human capital enhance productivity and sustain economic growth. Unlike the AGOUT–HDI relationship, which operates through agriculture-specific channels such as food security, rural

incomes, and farm employment, the RGDP–HDI relationship reflects economy-wide effects across all sectors. Thus, although agriculture contributes to GDP, the significant AGOUT–HDI nexus suggests that agriculture has a direct and distinct role in improving human development beyond its contribution to aggregate economic growth.

The results further indicate a unidirectional causal relationship from LFPRT to HDI, with no evidence of reverse causality (χ^2 = 99.20719, p < 0.01). This suggests that greater participation in productive economic activities contributes significantly to improvements in living standards, whereas improvements in human development alone may not necessarily increase labour force participation during the study period. Similarly, lnACGSF exerts a significant causal influence on HDI (χ^2 = 45.16126, p < 0.01), implying that improved access to agricultural finance enhances agricultural investment and productivity, which ultimately improves household welfare. However, no causal relationship is observed from HDI to lnACGSF.

The causality analysis further indicates a unidirectional causal relationship from LFPRT to lnAGOUT (χ^2 = 10.10084, p = 0.0388), whereas lnAGOUT does not significantly influence LFPRT. Likewise, lnACGSF significantly causes lnAGOUT (χ^2 = 12.84869, p = 0.0120), but the reverse relationship is not supported by the empirical evidence. These findings suggest that labour availability and access to agricultural finance remain important determinants of agricultural production in Nigeria.

With respect to lnRGDP, the results reveal a unidirectional causal relationship running from lnAGOUT to lnRGDP (χ^2 = 14.43714, p = 0.0060), whereas no evidence was found to support causality from lnRGDP to lnAGOUT. This finding reinforces the strategic importance of agriculture as a driver of Nigeria's economic growth during the study period. In addition, LFPART (χ^2 = 23.98753, p < 0.01) and the lnACGSF (χ^2 = 35.79908, p < 0.01) were both found to Granger-cause lnRGDP. These results suggest that improvements in labour utilization and increased financing to the agricultural sector contribute positively to overall economic performance.

The results indicate no evidence of reverse causality from HDI to either LFPART (χ^2 = 5.958235, p = 0.2023) or lnACGSF (χ^2 = 4.936565, p = 0.2939). This suggests that improvements in human development alone do not automatically increase labour force participation or expand access to agricultural credit. While better education, health, and living standards enhance individuals' capabilities, employment opportunities and access to agricultural finance depend largely on deliberate government policies, labour market conditions, institutional support, and financial sector reforms. These findings imply that improvements in human development must be complemented by targeted job creation programmes and inclusive agricultural credit policies before they can translate into higher employment and greater access to finance.

Overall, the Toda–Yamamoto results reveal both feedback and one-way causal relationships among the variables. The bidirectional causality between lnAGOUT

and HDI demonstrates that agricultural development and poverty reduction are mutually reinforcing processes. Meanwhile, the unidirectional effects of LFPRT and lnACGSF highlight the complementary roles of employment creation and improved agricultural financing in promoting sustainable agricultural growth and human development.

4.3 Post- estimation Diagnostic and Stability Tests

Table 4: *The Results of the Diagnostic Test*

Test	F-statistics	Obs* R-squared	Probability
Serial Correlation	3.328	14.078	0.089
Heteroscedasticity	1.677	23.881	0.201
Jaque Bera	0.466	-	0.792

Source: Computation Output Using E-views 10, 2026

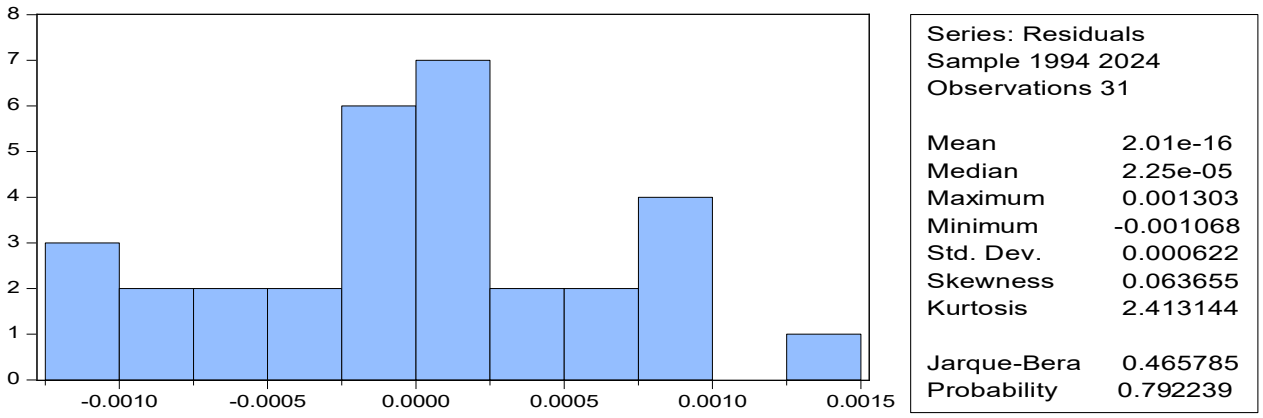


Figure 1: Test of Normality

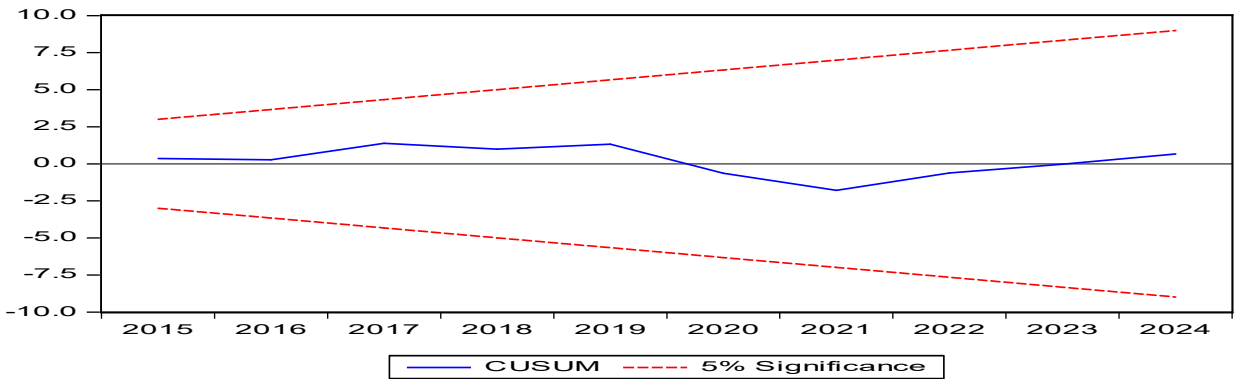


Figure 2: CUSUM Test

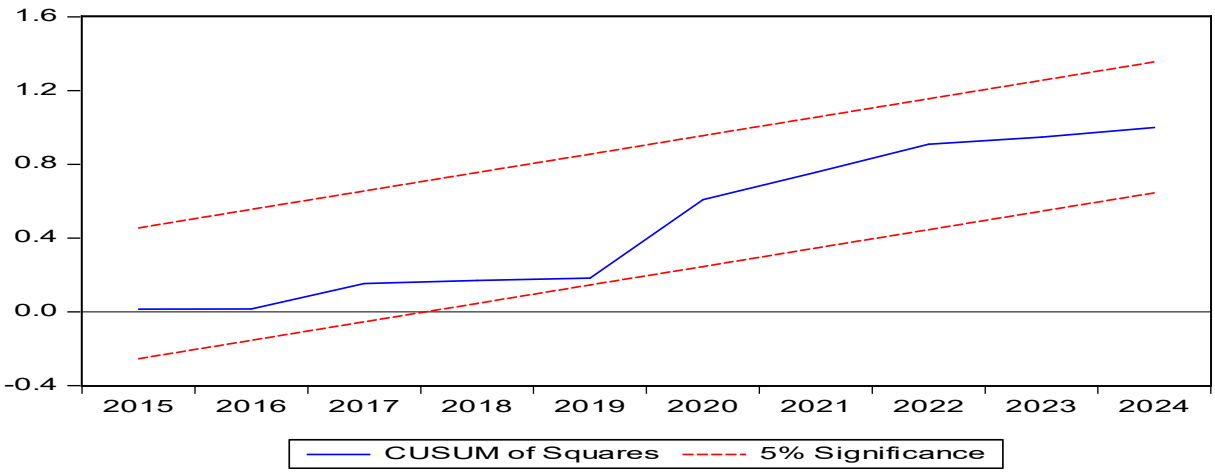


Figure 3: CUSUM of Square Test

To evaluate the adequacy of the estimated model, a series of post-estimation diagnostic tests were conducted as reported in Table 4. The Breusch–Godfrey Serial Correlation LM test indicates no evidence of serial correlation with value of 0.088, which is greater than 0.05, while the heteroscedasticity test confirms constant error variance (0.201). Likewise, the Jarque–Bera statistic of (0.466)and probability value of (0.792) shows that the residuals are normally distributed. The CUSUM and CUSUM of Squares plots reported in figure 2 and 3 further indicate that the estimated parameters remain stable throughout the sample period because both statistics lie within the 5% critical bounds.

Collectively, these diagnostic results confirm that the estimated Toda–Yamamoto model is statistically reliable and appropriate for policy inference.

5. Conclusion and Policy Recommendations

This study examined the causal relationship between agricultural output and poverty reduction in Nigeria, proxied by the Human Development Index (HDI), using the Toda-Yamamoto (1995) causality framework. The empirical findings established a bidirectional causal relationship between lnAGOUT and HDI, indicating that agricultural output and human welfare mutually reinforce each other over time. Specifically, increases in agricultural output enhance food availability, rural incomes, and employment, thereby improving human development, while improvements in education, health, and living standards strengthen the productive capacity required to sustain agricultural output. This feedback mechanism underscores the complementary nature of agricultural output and poverty reduction in Nigeria.

Based on the findings, the study recommends the following:

i. **Strengthen the agriculture–human development nexus** by implementing integrated rural development programmes that simultaneously promote agricultural productivity, healthcare, and education, given the bidirectional causality between agricultural output and HDI.
ii. **Expand agricultural finance** by strengthening the Agricultural Credit Guarantee Scheme Fund (ACGSF), improving access to credit through transparent and digitalized disbursement, particularly for smallholder farmers, women, and youth.
iii. **Improve labour productivity** through increased investment in agricultural mechanization, extension services, and rural skills development to enhance the contribution of labour force participation to agricultural output.
iv. **Monitor human development outcomes** by tracking HDI indicators alongside agricultural performance at the state and Local Government Area (LGA) levels to ensure that agricultural policies translate into measurable improvements in welfare.

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