

## Assessing the Dynamics of Green Finance and its Impact on Agricultural Productivity in Nigeria

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### ABSTRACT:

This study examines how green finance affects agricultural productivity in Nigeria. As climate change and environmental degradation threaten agricultural development, green finance provides a crucial mechanism for promoting sustainable agricultural practices. We used time-series analysis, representing green finance by green bonds, green credit, and green insurance, and measured agricultural productivity by the agricultural sector's contribution to Nigeria's gross domestic product. We employed Maximum Likelihood Estimation (MLE) in the Autoregressive Distributed Lag (ARDL) model to analyze the data. Our results indicate that, in the long run, green bonds, renewable energy production, annual rainfall, and temperature positively and significantly influence agricultural productivity. Green credit and green insurance show a positive but insignificant impact on agricultural productivity. Greenhouse gas emissions have a significant, negative impact on agricultural productivity, while regulatory quality has an insignificant, negative impact. Our study offers policymakers and stakeholders insights regarding the role of green finance in enhancing agricultural sustainability and productivity in Nigeria, shaping climate-resilient development strategies. We recommend that policymakers implement robust screening and monitoring processes for green bond issuance and green credit approvals.

**KEYWORDS:** *Green finance, Climate-smart agriculture, Agricultural productivity, Renewable energy, Environmental sustainability, Nigeria*

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## INTRODUCTION

Agricultural productivity in Nigeria remains low compared to that of other countries worldwide (FAO, 2020). Multiple factors hinder the country's agricultural productivity, including limited access to finance, inadequate infrastructure, and a lack of access to modern technology (Eboh, 2020). These challenges keep agricultural productivity low, limit economic growth, and lead to high poverty levels among smallholder farmers (Ogunbiyi, 2022). Green finance serves as a critical tool for supporting sustainable agricultural development (UNEP, 2016). Green finance uses financial instruments and mechanisms to promote environmentally sustainable economic growth and development (UNEP, 2016). Green finance covers financial activities that back environmentally sustainable projects and initiatives. These activities include investing in renewable energy, energy efficiency, sustainable agriculture, funding environmentally friendly, socially responsible projects, and green technologies. The green concept continues to transform the global modern economy, and capital from financial institutions and banks is increasingly important for investing in green products to support sustainable economic development. These institutions evaluate assets and risk, facilitate trade, mobilize savings, and assess investment profitability. International documents such as the Sustainable Development Goals (SDGs), the Paris Agreement, and the UN Guiding Principles on Business and Human Rights enshrine the underlying principles, values, and objectives of green finance. Green finance also develops methods and approaches to identify, evaluate, and integrate risks from climate variability into decision-making (Odili et al., 2024). By financing environmentally friendly agricultural practices, green

finance promotes sustainable agricultural development and improves agricultural productivity (Ogunbiyi, 2022).

Agricultural productivity statistics in Nigeria show that crop yields are significantly lower than the global average. For example, the country's maize yield is approximately 1.8 tons per hectare, compared to the global average of 5.6 tons per hectare (FAO, 2020). Nigeria's agricultural productivity has been declining over the years. For example, the country's agricultural productivity index declined from 105.6 in 2015 to 95.6 in 2020 (World Bank, 2020). Only about 1% of Nigeria's agricultural land is irrigated, making the sector highly vulnerable to climate change and weather-related shocks (CBN, 2020). Similarly, Nigeria's livestock productivity is lower than that of other countries. For example, the country's milk production per cow is approximately 1,000 litres per year, compared to the global average of 2,500 litres per year (FAO, 2020). Many livestock farmers in Nigeria lack access to veterinary services, making it difficult for them to maintain healthy and productive animals (USAID, 2020).

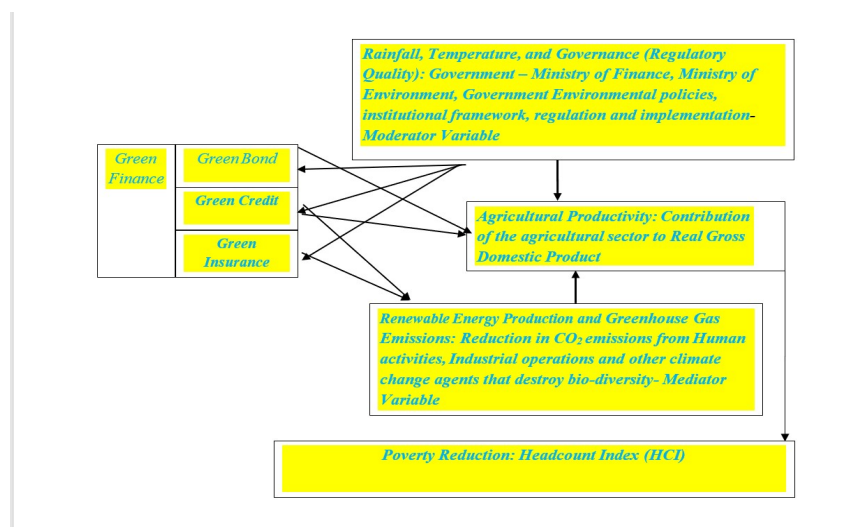
Several challenges impede agricultural productivity in Nigeria, including climate change. The country experiences more frequent and severe weather-related shocks, such as droughts and floods, which significantly impact agricultural productivity (IPCC, 2020). Soil degradation also poses a major threat to agricultural productivity in Nigeria. Erosion, nutrient depletion, and salinization degrade the country's soils and drastically reduce productivity (FAO, 2020). Many Nigerian farmers lack access to finance, which hinders their ability to invest in their farms and improve productivity (CBN, 2020). Additionally, many farmers in Nigeria lack access to technology, such as irrigation systems, tractors, and other machinery, which directly impacts agricultural productivity (FAO, 2020).

Prior studies have shown the urgent need for innovation and investment. Adeyinka (2018) revealed stifled sector productivity linked to credit scarcity and weak infrastructure. Eboh (2020) demonstrated how green finance can drive the adoption of transformative, sustainable farming practices. Yet, Adebayo (2020) warned that green finance's impact can be constrained, risking unrealized progress. Okoroafor (2019) stressed that the effects of green finance on productivity demand bold exploration. This study steps forward to dissect the dynamics and critical effects of green finance on Nigeria's agricultural productivity.

## LITERATURE REVIEW

### Conceptual Framework

The Conceptual Framework assumes that green finance contributes to agricultural productivity in Nigeria, while climate change and environmental degradation negatively affect it. The Sustainable Livelihoods Framework (SLF) also builds on the green finance concept by emphasizing the role of financial instruments and mechanisms in supporting environmentally friendly and sustainable projects. Green finance increases agricultural productivity by providing access to finance for climate-smart agricultural practices, while climate change mitigation and adaptation efforts boost productivity by lessening agriculture's vulnerability. Government policies and regulations shape the availability and accessibility of green finance for agricultural development. Figure 1 details the relationships between green finance and agricultural productivity in Nigeria.



### ***Theoretical Framework***

The theoretical framework for this study is based on the Sustainable Livelihoods Framework (SLF) and the Stakeholder Theory. Sustainable Livelihoods Framework (SLF): The Sustainable Livelihoods Framework (SLF) was propounded by Chambers & Conway (1992), Robert and Gordon (1992). This framework identifies five types of assets critical to achieving sustainable livelihoods: human capital, social capital, natural capital, physical capital, and financial capital. The SLF posits that households and individuals use various assets and strategies to achieve their livelihood goals. The framework identifies five types of assets that are critical for achieving sustainable livelihoods: Human capital: skills, knowledge, and health; social capital: social networks, relationships, and institutions; natural capital: natural resources, such as land, water, and biodiversity; physical capital: infrastructure, technology, and equipment; financial capital: access to financial services, credit, and savings. The SLF also identifies three key strategies that households and individuals use to achieve their livelihood goals: Diversification: diversifying income sources and assets to reduce risk; Intensification: increasing the productivity of existing assets and activities; and Innovation: adopting new technologies, practices, and institutions to improve livelihoods. The Stakeholders Theory: The theory was propounded by Freeman (1984), who argued that financial institutions must play an important role in the transition to environmental sustainability to help society combat climate change. This implies that financial institutions should integrate the sustainability concept into their financial analysis and investment portfolios. Managers must therefore meet the needs of the host community, employees, and government agencies.

### ***Review of Green Finance, Agricultural Productivity and Poverty Reduction: Nigerian Perspective***

According to Evbuomwan (2016), green finance has emerged as an important policy instrument for promoting sustainable economic development by directing financial resources toward environmentally responsible investments. In agriculture, green finance encompasses green credit, climate-smart agricultural financing, green bonds, sustainable agricultural funds, and other financial mechanisms designed to enhance productivity while minimizing environmental degradation. Within the Nigerian context, green finance is increasingly recognized as a critical tool for addressing agricultural challenges, improving rural livelihoods, and reducing poverty.

Nigeria's agricultural sector remains a major contributor to employment and national output, providing livelihoods for a significant proportion of the rural population. Agriculture contributes substantially to the country's Gross Domestic Product (GDP) and serves as the primary source of income for many households. However, the sector continues to face challenges, including inadequate financing, low technological adoption, climate change impacts, poor infrastructure, and limited access to modern farming inputs. These constraints have contributed to low agricultural productivity and persistent rural poverty.

#### ***Green Finance and Agricultural Productivity***

The theoretical foundation linking green finance and agricultural productivity is based on the premise that access to sustainable financing enables farmers to invest in improved technologies, climate-resilient inputs, irrigation systems, renewable energy solutions, and environmentally sustainable farming practices. Such investments enhance efficiency, increase crop yields, improve resource utilization, and strengthen resilience against climate-related shocks (Ayo-Balogun, 2024).

Empirical studies in Nigeria indicate that green financing initiatives positively influence agricultural output. Green finance provides farmers with access to affordable credit facilities, enabling them to adopt modern agricultural technologies and climate-smart practices. Research examining green financing and agricultural sector growth in Nigeria found a positive relationship between green financial investments and agricultural output, suggesting that environmentally targeted financing can stimulate sustainable agricultural development.

Furthermore, access to agricultural finance has been consistently identified as a significant determinant of farm productivity. Financial support allows farmers to acquire improved seeds, fertilizers, mechanized equipment, and irrigation facilities, all of which contribute to increased productivity. Several studies have shown that agricultural financing enhances production efficiency and facilitates the transition from subsistence to commercial farming.

#### ***Agricultural Productivity and Poverty Reduction***

Agricultural productivity is widely regarded as a key pathway to poverty reduction, particularly in developing economies where a large proportion of the poor depend on agriculture for their livelihoods. Increased productivity raises farm incomes, improves food security, generates employment opportunities, and stimulates rural economic growth (Ogunjobi, 2022).

The literature demonstrates a strong relationship between agricultural productivity and poverty alleviation in Nigeria. Enhanced productivity increases household income, improves access to education and healthcare, and reduces vulnerability among rural populations. Studies indicate that agricultural growth has

a greater impact on poverty reduction than growth in many other sectors because it directly affects low-income households engaged in farming.

Evidence from Nigeria suggests that agricultural productivity contributes to poverty reduction through multiple channels, including increased food availability, higher agricultural earnings, employment creation, and broader rural development. However, productivity gains are often constrained by inadequate financing, poor market access, and weak institutional support systems.

#### ***Green Finance and Poverty Reduction***

Green finance contributes to poverty reduction both directly and indirectly. Directly, it improves access to financial resources for smallholder farmers, enabling them to invest in productive activities that increase income. Indirectly, green finance promotes environmental sustainability, ensuring the long-term viability of agricultural production systems and reducing vulnerability to climate-related risks.

Research on agricultural financing and poverty alleviation in Nigeria reveals that access to agricultural credit significantly improves economic performance and supports rural poverty reduction. Financial interventions such as commercial agricultural loans, agricultural credit guarantee schemes, and government-supported financing programs have demonstrated positive effects on agricultural output and household welfare.

Green finance also supports climate adaptation strategies, helping farmers cope with droughts, floods, and changing weather patterns. By enhancing resilience, green finance reduces the likelihood of income losses and food insecurity among vulnerable rural populations. This contributes to sustainable poverty reduction and improved living standards.

#### ***Challenges of Green Finance in Nigeria***

Despite its potential benefits, implementing green finance in Nigeria faces several challenges. These include:

- Limited awareness of green financial products among farmers.
- High transaction costs are associated with agricultural lending.
- Weak institutional and regulatory frameworks.
- Limited access to formal financial services in rural areas.
- Inadequate climate-risk assessment mechanisms.
- Poor infrastructure and extension services.
- Low financial literacy among smallholder farmers.

These challenges have constrained the scale and effectiveness of green financing initiatives, limiting their impact on agricultural productivity and poverty reduction.

#### ***Research Gap***

Although substantial literature exists on agricultural finance, agricultural productivity, and poverty reduction in Nigeria, studies specifically examining the integrated relationship between green finance, agricultural productivity, and poverty reduction remain limited. Most existing studies focus on conventional agricultural financing without adequately accounting for environmental sustainability. Additionally, empirical evidence on the long-term impacts of green financial instruments on rural welfare and poverty reduction in Nigeria remains insufficient.

The reviewed literature suggests that green finance has significant potential to enhance agricultural productivity and reduce poverty in Nigeria. By facilitating access to sustainable financial resources, green finance promotes technological adoption, climate resilience, increased agricultural output, and improved rural livelihoods. However, institutional, financial, and infrastructural constraints continue to limit its effectiveness. Future research should focus on developing comprehensive frameworks that integrate green finance, agricultural productivity, and poverty reduction to support sustainable agricultural transformation and inclusive economic development in Nigeria.

## **METHODOLOGY**

The study period ranges from 1990 to 2023. The variables analyzed are Agricultural production– dependent variables and Green Bond (GB), Green Credit (GC), Green Insurance (GI), Renewable Energy Production (REP), Greenhouse Gas Emissions (GHG), Annual Rainfall, Temperature, and Regulatory Quality (RQ) as independent variables. These variables represent key components of green finance and factors that affect agricultural production. By using these independent variables, the study provided a nuanced understanding of the policy implications for promoting green finance, reducing emissions, and achieving sustainable agricultural productivity.

#### ***Model Specification***

In line with Townsend (2006), in which financial products and investments are conceptualized as determinants of sustainable growth in the context of efficient financial services and credit intermediation to the real sectors, which activates sustainable economic services and enhance sustainable economic outcome, this study conceptualizes green finance as determinants of agricultural productivity in the context of provision of environmentally friendly financial products and credit intermediation to the agricultural sector,

which activates sustainable agricultural productivity. This relationship is specified in a Likelihood Function and a Log-Likelihood Function in equations 1 and 2, respectively.

$$L(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \sigma^2 | ACRGDP, GB, GC, GI, REP, GHG, ARF, TP, RQ) = [1/\sqrt{(2\pi\sigma^2)}] \exp[-(ACRGDP - \beta_0 - \beta_1GB_i - \beta_2GC_i - \beta_3GI_i - \beta_4REP_i - \beta_5GHG_i - \beta_6ARF_i - \beta_7TP_i - \beta_8RQ_i)^2 / (2\sigma^2)] \text{-----eqn.1}$$

To simplify the calculation, the log-likelihood function was used.

$$\log L(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \sigma^2 | ACRGDP, GB, GC, GI, REP, GHG, ARF, TP, RQ) = -n/2\log(2\pi) - n/2\log(\sigma^2) - 1/(2\sigma^2) \sum (ACRGDP - \beta_0 - \beta_1GB_i - \beta_2GC_i - \beta_3GI_i - \beta_4REP_i - \beta_5GHG_i - \beta_6ARF_i - \beta_7TP_i - \beta_8RQ_i)^2 \text{-----eqn.2}$$

$$ACRGDP = \beta_0 + \beta_1GB + \beta_2GC + \beta_3GI + \beta_4REP + \beta_5GHG + \beta_6ARF + \beta_7TP + \beta_8RQ + \varepsilon \text{-----eqn.3}$$

ACRGDP: Agricultural Sector Contribution to Real Gross Domestic Product in Nigeria (Naira)

GB: Green Bond issuance (USD million)

GC: Green Credit provision (USD million)

GI: Green Insurance premiums (USD million)

REP: Renewable Energy Production (Gigawatt-hours, GWh)

GHG: Greenhouse Gas emissions (million tons of CO2 equivalents, MtCO2e)

ARF: Annual rainfall (millimeters, mm)

TP: Temperature (Celsius scale, oC)

RQ: Regulatory Quality Index (index score)

ε: Error term, assumed to be normally distributed with mean 0 and variance σ<sup>2</sup>

n is the sample size.

The parameter MLEs were obtained by maximizing the log-likelihood function with respect to β<sub>0</sub>, β<sub>1</sub>, β<sub>2</sub>, β<sub>3</sub>, β<sub>4</sub>, β<sub>5</sub>, β<sub>6</sub>, β<sub>7</sub>, β<sub>8</sub>, and σ<sup>2</sup> using numerical optimization methods. The coefficients (β<sub>1</sub>, β<sub>2</sub>, β<sub>3</sub>, β<sub>4</sub>, β<sub>5</sub>, β<sub>6</sub>, β<sub>7</sub>, β<sub>8</sub>) represent the change in ACRGDP associated with a one-unit change in the respective independent variable, holding all other variables constant. The significance of each coefficient was tested using p-values.

**Data Estimation Technique**

Maximum Likelihood Estimation (MLE) was employed on the Autoregressive Distributed Lag (ARDL) model. MLE is a method for estimating the parameters of a statistical model (β<sub>0</sub>, β<sub>1</sub>, ..., β<sub>8</sub>, and σ<sup>2</sup> in this case) by finding the values that maximize the likelihood of observing the data given the model. The idea is to maximize the likelihood function of the ARDL model, which is typically assumed to follow a multivariate normal distribution.

**Description of Research Variables**

**Table 1: Description, identifier, measurement, expected signs, and sources of data**

Variable	Identifier	Description and Justification	<i>a priori</i> Source signs	
Agricultural Productivity	ACRGDP	Agricultural Sector Contribution to Real Gross Domestic Product in Nigeria. This measure is often referred to as the Agricultural Value Added (AVA) or agricultural GDP. It represents the value of agricultural production, minus the value of inputs used in production, adjusted for inflation.		CBN Statistical Bulletin
Green bond	GB	Green bond is a fixed-income security designed to support specific climate-related or environmental projects. It may also be referred to as climate bond or sustainable bonds. It represents innovative financing mechanism for environmentally friendly projects.	+ve	WDI
Green credit	GC	This is loan facilities granted to individuals and organizations for investment in green projects. It is usually initiated by the government to incentivize stakeholders to contribute to environmental preservation and sustainable practices. It encourages lending for green projects, reducing emissions and promoting sustainability.	+ve	WDI
Green insurance	GI	GI is insurance policy that covers the design, production, and use of sustainable products, or the liability associated with their production and use. They also indemnify against the environmental consequence of potential climate change decisions or indecisions of	+ve	NIID

		executives. It provides risk mitigation and management for green investments.		
Renewable Energy Production	REP	REP relates to money expended in the production or generation of energy from natural resources, such as sunlight, wind, geothermal, hydropower, ocean, and biomass (wood, charcoal, and dung). It is a key aspect of reducing greenhouse gas emissions.	+ve	NCDC
Greenhouse gas emissions	GHG	Changes in atmospheric level due to greenhouse gas emissions from water, forest, and land-use. This factor evaluates a company's efforts to monitor, reduce, and offset the impact of pollutants, greenhouse gases, and other harmful substances. GHG is a critical indicator of environmental degradation, influencing policy decisions and green finance effectiveness.	+ve	NCDC
Annual Rainfall	ARF	Annual rainfall measures the average rainfall in a year. In this study, annual rainfall is measured in millimeters (mm)	-ve or +ve	NIMET
Temperature	TP	Temperature is the hotness or coldness of the atmosphere at a given time. Extreme temperatures such as heat waves or frost can have devastating effects on agricultural production. In this study, temperature is measured in Celsius scale (oC)	-ve or +ve	NIMET
Governance	RQ	Governance (regulatory quality) index measures perceptions of government capacity to formulate and implement effective policies and its regulatory ability. This includes environmental regulation and implementation. RQ affects the effectiveness of green finance policies and instruments.	-v	WGI

**RESULT AND DISCUSSIONS**

Descriptive statistics is one approach to descriptive analytics. The descriptive statistics are presented in Table 2.

**Table 2: Descriptive Statistics**

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	JB Prob.	Obs.
ACRGDP	12637.52	8032.640	47944.06	106.6300	13415.26	1.044342	3.099349	0.045177	34
GB	450.0749	459.4946	1183.840	-0.43616	389.4512	0.198013	1.600127	0.223315	34
GC	24.52214	17.38853	75.44773	1.661000	21.70427	0.631985	2.022894	0.163995	34
GI	2.207854	2.255974	6.375314	0.108567	2.011363	0.532531	2.162360	0.272396	34
REP	908309.7	498500.0	5314790.	8520000.	1176024.	2.459637	8.783480	0.000000	34
GHG	328.2329	327.1000	395.4656	241.4000	41.12350	-0.04996	1.967286	0.466495	34
ARF	114.7134	114.5998	120.6200	106.8500	2.274631	-0.41743	7.526656	0.000000	34
TP	26.79383	26.75500	27.48000	26.05000	0.363109	0.035196	2.227941	0.653293	34
RQ	-1.10677	-1.08	-0.82	-1.38	0.112269	-0.02598	3.661471	0.732099	34

**Source: Authors computation, 2025**

The standard deviation indicates that ACRGDP and REP are dispersed from their respective means, suggesting some inconsistency in the data. The values of skewness explain that the variables are normally skewed either to the left or right. From the descriptive analysis, ACRGDP, REP, ARF, and RQ have Kurtosis values greater than 3, indicating that these variables are highly peaked (leptokurtic), while other variables with Kurtosis values less than 3 are said to be lowly peaked (platykurtic). The Jarque-Bera (JB) probability values for ACRGDP, REP, ARF, and RQ are less than 0.05, indicating that the data are not normally distributed, whereas the other variables with JB probability values greater than 0.05 are normally distributed. Since the data are not normally distributed, a logarithmic transformation was used.

#### *Stationarity Tests*

The Augmented Dickey-Fuller (ADF) approach was used in this study as presented in Table 3.

**Table 3: Stationarity tests**

Variables	5% levels	critical 5% levels	critical 5% levels	critical 5% levels	critical Remarks
	At Level	Prob.	First - order	Prob.	
LOG(ACRGDP)	-1.119420	0.9103	-4.252426	0.0105	I(1)
LOG(GB)	-4.873722	0.0024	-	-	I(0)
LOG(GC)	-1.691413	0.7374	-4.730725	0.0033	I(1)
LOG(GI)	-1.864349	0.6500	-5.163678	0.0011	I(1)
LOG(REP)	-3.822314	0.0278	-	-	I(0)
LOG(GHG)	-7.157875	0.0000	-	-	I(0)
LOG(ARF)	-4.953306	0.0018	-	-	I(0)
LOG(TP)	-5.768906	0.0002	-	-	I(0)
RQ	-6.593903	0.0000	-	-	I(0)

**Source: Authors, 2025**

As seen in Table 3, the logged data for GB, REP, GHG, ARF, TP, and RQ are stationary at levels, but ACRGDP, HCI, GC, and GI are non-stationary at level  $f$ ; taking the first difference of the series makes them stationary. The t-statistic values are tested at the 5 percent significance level. Hence, variables are adjudged stationary if their respective probability values fall below 0.05 at either level, that is, I(0) or I(1). This result implies that the variables are integrated into varying orders and differences (even though none of the variables is integrated at second differences), which informed the use of the Autoregressive Distributed Lag (ARDL) technique for the study.

#### *ARDL Estimation*

The ARDL estimation was carried out to assess the impact of green finance on agricultural productivity in Nigeria. The outcome of the bounds test approach to co-integration, which measures the existence of a long-run relationship in the model, is presented in Table 4.

The results of the bounds test showed that the F-statistic value is 5.392967. It is noted that the reported F-statistics exceed the bounds' critical value at the 5 percent level, implying a long-run equilibrium relationship between different orders of the dependent and independent variables. This means that the relationship between green finance and agricultural productivity in Nigeria follows a long-run path.

Table 4: Bounds test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.392967	10%	2.26	3.34
k	8	5%	2.55	3.68
		1%	3.15	4.43

*Source: Authors, 2025*

#### *Long-run Estimates*

The long-run estimates are as presented in Table 5.

Table 5: Long-run estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(GB)	0.163267	0.036717	4.446622	0.0000
LOG(GC)	0.450062	0.270506	1.663782	0.1244
LOG(GI)	0.079699	0.053867	1.479548	0.1671
LOG(REP)	0.063485	0.025930	2.448332	0.0323
LOG(GHG)	-2.848747	0.462818	-6.155221	0.0000
LOG(ARF)	1.986300	0.498593	3.983806	0.0021
LOG(TP)	1.285648	0.317507	4.049196	0.0001
RQ	-0.070822	0.356847	-0.198467	0.8463

*Source: Authors, 2025*

The results presented in Table 5 indicate that, in the long run, green bonds, renewable energy production, annual rainfall, and temperature have a positive and significant impact on agricultural productivity. Green credit and green insurance had a positive but insignificant impact on agricultural productivity. Greenhouse gas emissions had a negative, significant impact, while regulatory quality had a negative, insignificant impact on agricultural productivity in Nigeria.

#### *Error Correction Mechanism (ECM)*

The ECM was employed to examine the nature of the short-run adjustment process towards the long-run equilibrium. It is noteworthy that the ECM (-1), which is the residual value, was negative and significant in Model 1. The ECM coefficient of -0.153194 showed that approximately 15.3% of the errors associated with the short-run adjustment mechanism is corrected per period in the model. This further shows that the system has a relatively slow adjustment speed and may also take a long time to converge to its equilibrium state. Dividing 1 by the absolute value of the ECM coefficient, = 6.53 years, shows that it will take approximately 6.5 years for agricultural productivity to adjust to any disequilibrium in the short run arising from green finance.

Regression equations using time-series data may include a time index or a trend variable. The positive, significant trend coefficient indicates that the observed impact of the independent variables on the dependent

variable is not directly observable but is highly correlated with time in the ECM. This implies that the impact of green financing on agricultural productivity varies over time, explaining the different signs and levels of significance observed for the explanatory variables in the ECM.

**Table 6: Error correction mechanism**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-168.6917	23.30017	-7.239936	0.0000
@TREND	0.052734	0.009663	5.457388	0.0002
DLOG(ACRGDP(-1))	0.777285	0.169226	4.593186	0.0008
DLOG(GB)	0.025300	0.028949	0.873930	0.4008
DLOG(GB(-1))	-0.269310	0.041594	-6.474777	0.0000
DLOG(GC)	0.310145	0.214045	1.448972	0.1752
DLOG(GC(-1))	-0.565499	0.226895	-2.492337	0.0299
DLOG(GI)	0.491048	0.095176	5.159365	0.0003
DLOG(GI(-1))	0.119165	0.051836	2.298907	0.0421
DLOG(REP)	0.665432	0.207220	3.211240	0.0035
DLOG(GHG)	-0.954760	1.195415	-0.798685	0.4414
DLOG(ARF)	1.770784	0.254486	6.958273	0.0000
DLOG(ARF(-1))	-3.282574	1.117773	-2.936710	0.0135
DLOG(TP)	-0.194529	0.086817	-2.240674	0.0338
DLOG(RQ)	-2.338622	0.399978	-5.846883	0.0000
ECM(-1)	-0.153194	0.021094	-7.262590	0.0000

*Source: Authors, 2025*

#### **Diagnostic Tests**

The diagnostic tests presented in Table 7 indicate that there is no substantial evidence of serial correlation, model misspecification, heteroskedasticity, or abnormal distribution in the ARDL model. This indicates that the statistical assumptions hold, reinforcing the reliability of our analysis. Moreover, the diagnostic tests indicated that the estimated coefficients in the model are robust and not influenced by serial correlation, model misspecification, or heteroskedasticity. This reinforces the trustworthiness of the coefficients and their association with the variables in the analysis. To assess the stability of these estimated coefficients, the study scrutinized the cumulative sum of recursive residuals and the cumulative sum of squares, graphically represented in Figures 2 and 3. These visual representations offer valuable insights into whether our coefficients remain consistent over time or exhibit significant fluctuations. Stable coefficients are essential for the accuracy and trustworthiness of the ARDL model's predictions.

The diagnostic test results are presented in Table 7.

**Table 7: Diagnostic tests**

Test	Prob.	Remark
Serial correlation	0.5028	Residuals are not serially correlated
Heteroskedasticity	0.5360	Residuals are homoscedastic
Jarque-Bera	0.6390	Residuals are normally distributed

Source: Authors, 2025

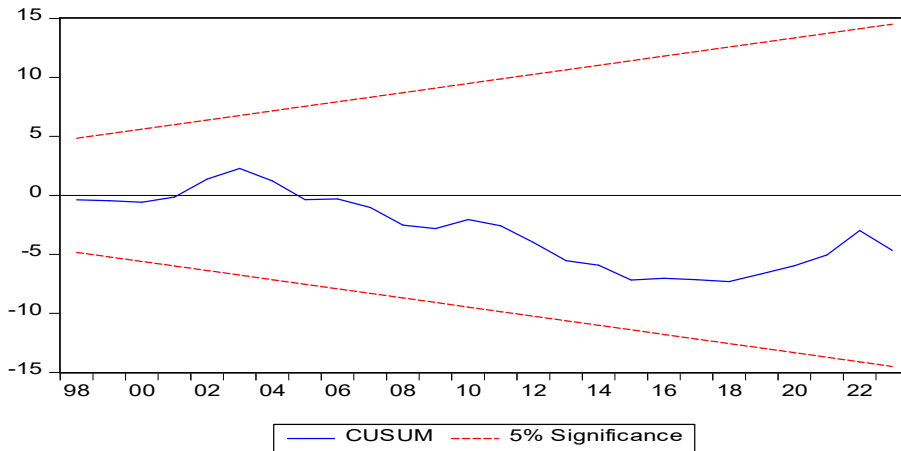


Figure 2 CUSUM test; Source: Authors, 2025

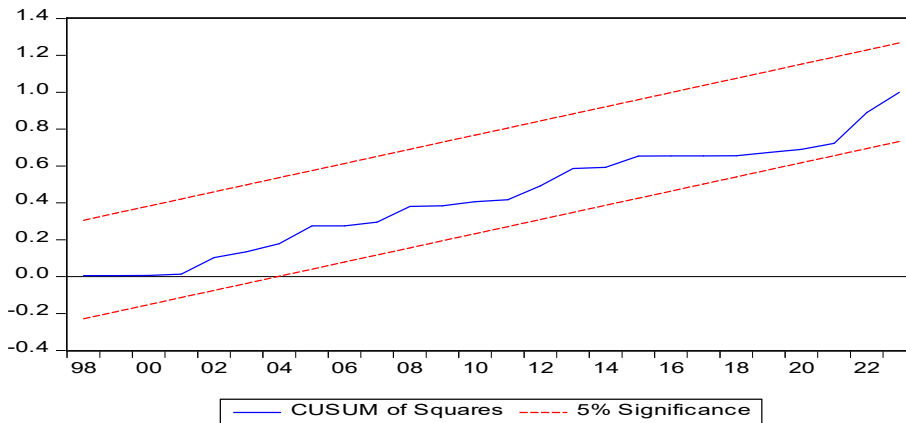


Figure 3 CUSUMSQR test: Source: Authors, 2025

The stability of the long-run relationship between the independent and dependent variables is checked. The CUSUM test was used to test for constancy of long-run parameters. The tests are applied to the model's residuals. The plot of the CUSUM statistics stays within the 5% significance level; therefore, the estimates are stable. Next, the study assessed the stability of the long-run relationship by employing CUSUM-squared (CUSUMSQR) tests to examine the constancy of long-run parameters. These tests were conducted on the model's residuals. The CUSUM-squared statistics, when plotted, consistently remained within the 5% significance level, indicating stable estimates. This suggests that the coefficients remain consistent over the

entire study period. Figures 4.1 and 4.2 depict that the parameters fall within the upper and lower critical bounds at a 5% significance level.

### ***Discussions***

Green bonds (GB) significantly increase agricultural productivity in the long run, indicating that GBs account for a significant increase in agricultural productivity. This aligns with the notion that green bonds provide crucial funding for agricultural projects with positive environmental outcomes, such as renewable energy and clean transportation, by mobilizing capital for a low-carbon transition and promoting sustainable development. Also, green bonds align financial markets with sustainability goals, offer potential tax benefits and low-cost, long-term capital to issuers, and provide agro-investors with opportunities for socially responsible investing and diversification. Studies such as Geng et al. (2024), Idrissu et al. (2025), and Usman and Mnyimanga (2025) suggest that green finance can increase financial inclusion, which, in turn, significantly drives agricultural production. According to a study by Kapa et al. (2022), the issuance of green bonds increased crop yields and farmers' income, underscoring the potential of financial incentives to drive sustainable agricultural practices and improve overall agricultural sector performance and poverty reduction. The study shows that green credit (GC) had a positive, though statistically insignificant, impact on agricultural GDP, indicating that GC did not significantly influence agricultural sector productivity in the long run. Green credit may marginally influence agricultural productivity in Nigeria due to several intertwined factors, including limited access to credit for key sectors, such as agriculture; ineffective use of credit by smallholders, who often take loans for consumption rather than productive inputs; and institutional weaknesses, such as high interest rates and cumbersome procedures. Furthermore, other challenges, such as a lack of collateral, poor infrastructure, and macroeconomic factors, can also dampen the impact of credit on productivity, even when it is available. The insignificant impact of green credit was supported by Usman and Mnyimanga (2025), Monday and Chukwuemeka (2023), and Oyedele (2019), who argued that green credit could have a marginal impact on agricultural productivity if used inefficiently.

The study found that green insurance (GI) marginally increased agricultural productivity in the long run. This implies that green insurance had no significant impact on agricultural productivity. Many Nigerians are unaware of insurance's benefits, and there is a general lack of trust in the sector, leading to low patronage and participation. Insurance coverage, especially in rural areas, is often inadequate, offering only partial benefits and leaving patients to cover significant out-of-pocket expenses. Poor service quality from insurance providers further undermines confidence and reduces uptake, hindering the potential benefits of the system.

### **CONCLUSION**

This study investigated the impact of green finance on agricultural productivity in Nigeria. Based on the ARDL estimation used for the data analysis, the study found that the impact of green finance on agricultural productivity followed a long-run path. From the long-run estimation, the following findings were made: results showed a direct, positive impact of green bonds on agricultural productivity and poverty reduction, indicating that green bonds had a considerable impact on agricultural production in Nigeria. It is therefore concluded that green bonds are among the variables in green finance that influence agricultural productivity in Nigeria. Similarly, the results indicated that green credit had a positive, though statistically insignificant, impact on agricultural productivity. This means that green credit marginally increased agricultural productivity. This supports the argument that green credit could be given priority in Nigeria. Thus, the study concluded that green credit is not among the factors that influence agricultural productivity in Nigeria. Green insurance was found to have a statistically insignificant impact on agricultural productivity. Renewable energy production, annual rainfall, and temperature had a positive and significant impact on agricultural productivity. Greenhouse gas emissions had a negative, significant impact, while regulatory quality had a negative, insignificant impact on agricultural productivity. In Nigeria. This study concludes that green finance is still in its infancy and has not had a considerable impact on agricultural productivity in Nigeria.

Based on the above, the study recommends that Nigeria should issue more green bonds and make them more attractive to all economic agents to increase the pool of green finance. It should appropriately allocate a portion of the federal allocation to local governments, specifically for green financing, to expand its reach to smallholder farmers. In addition, policymakers should implement more robust screening and monitoring processes. Credit approval criteria should emphasize verifiable emission-reduction targets, and borrowers should be required to report on environmental outcomes at regular intervals. Incentives, such as interest rate discounts or extended repayment periods, could be offered to meet or exceed environmental performance benchmarks. Finally, insurance policy should be designed to cover the interests of all the farmers so as to encourage their participation. Hence, farmers in Nigeria should be considered in insurance and investment policies to enhance agricultural productivity.

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