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GREEN FINANCE AND SUSTAINABLE AGRICULTURAL GROWTH: INSIGHTS FROM WEST AFRICA

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ABSTRACT----------
This study examined the effect of green finance on sustainable agricultural growth in West Africa over the period 2010–2025. Specifically, the study investigated the effects of climate finance flows, green bonds, and renewable energy investment on sustainable agricultural growth, while controlling for gross domestic product per capita and inflation. An ex post facto research design was adopted using balanced panel data for sixteen West African countries. The study employed the two-step System Generalized Method of Moments (System GMM) estimator to account for endogeneity, unobserved country-specific effects, and the dynamic nature of sustainable agricultural growth. Model validity was assessed using the Arellano–Bond serial correlation tests and the Hansen J-test of over-identifying restrictions. The findings revealed that climate finance flows, green bonds, and renewable energy investment each have a positive and statistically significant effect on sustainable agricultural growth in West Africa. The study concludes that green finance is an important catalyst for achieving sustainable agricultural growth in West Africa by promoting investment in climate-smart agriculture, renewable energy technologies, and environmentally sustainable production systems. Accordingly, the study recommends that governments strengthen climate finance mobilization, promote the development of green bond markets and renewable energy investment, and maintain a stable macroeconomic and institutional environment to maximize the contribution of green finance to sustainable agricultural development in the region.

KEYWORDS: *Green finance, climate finance flows, green bonds, renewable energy investment, sustainable agricultural growth, System* ----------

1.0 INTRODUCTION

Agriculture remains one of the most important sectors in West African economies, serving as a major source of employment, income generation, food security, and foreign exchange earnings. The sector employs more than half of the region's labour force and contributes significantly to the Gross Domestic Product (GDP) of most West African countries (AbdulKareem et al., 2025). Regardless of its strategic importance, agricultural productivity in the region continues to be constrained by inadequate financing, climate change, land degradation, limited adoption of modern technologies, weak infrastructure, and low investment in sustainable farming practices (Ibrahim et al., 2026; Mapanje et al., 2023). These challenges have intensified concerns about the ability of the agricultural sector to meet the growing food demands of an increasing population while preserving natural resources for future generations, thereby underscoring the need for innovative financing mechanisms that support sustainable agricultural development (Addai et al., 2024).

The increasing frequency of climate-related events, including prolonged droughts, floods, desertification, erratic rainfall patterns, and biodiversity loss, has heightened the vulnerability of agricultural systems across West Africa (Ibrahim et al., 2026; Degila et al., 2022). Smallholder farmers, who account for the majority of agricultural producers in the region, are particularly exposed to these environmental risks due to limited financial capacity and inadequate access to climate-resilient technologies, which constrain their ability to adopt sustainable agricultural practices (Mapanje et al., 2023; Addai et al., 2024). Consequently, there is growing recognition that achieving sustainable agricultural growth requires innovative financing mechanisms capable of supporting environmentally responsible agricultural investments while enhancing resilience to climate change through increased access to green finance, climate-smart technologies, and sustainable investment frameworks (Mhlanga, 2024; Abid, 2026;).

Green finance has emerged as a strategic policy instrument for promoting sustainable development by directing financial resources toward environmentally friendly and climate-resilient economic activities. It encompasses a broad range of financial instruments and services including green credit, green bonds, climate finance, concessional loans, environmental risk insurance, carbon finance, blended finance, and sustainability-linked investments that encourage investments with positive environmental and social outcomes. In agriculture, green finance facilitates the adoption of climate-smart farming practices, renewable energy technologies, efficient irrigation systems, sustainable land management, agroforestry, organic farming, and other innovations that improve productivity while minimizing environmental degradation (Mei et al., 2022; Mo et al., 2023).

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Recent evidence suggests that green finance plays a significant role in enhancing sustainable agricultural development by improving farmers' access to capital, encouraging technological innovation, increasing resource-use efficiency, and reducing greenhouse gas emissions. For example, Yuan et al. (2024) found that green finance significantly promotes high-quality agricultural development by facilitating technological progress and improving environmental performance. Similarly, Addai et al. (2024) reported that green finance, particularly when complemented by digital technologies, positively influences sustainable agricultural development in Sub-Saharan Africa. Ibrahim et al. (2026) further demonstrated that the interaction between green finance, digital technology, and environmental sustainability contributes substantially to agricultural transformation in West African economies.

In recent years, West African countries have intensified efforts to integrate sustainability considerations into agricultural and financial sector policies. Governments, central banks, development finance institutions, and international development partners have introduced various initiatives aimed at promoting climate-smart agriculture, renewable energy adoption, sustainable irrigation, afforestation, and environmentally responsible agricultural investments. Regional frameworks such as the Economic Community of West African States (ECOWAS) Agricultural Policy (ECOWAP), alongside global commitments under the Paris Agreement and the United Nations Sustainable Development Goals (SDGs), have further reinforced the importance of mobilizing green finance to accelerate agricultural transformation and climate resilience. Nevertheless, the scale of green financing available to agriculture remains insufficient due to limited financial inclusion, underdeveloped capital markets, weak institutional capacity, inadequate regulatory frameworks, and low awareness among farmers and financial institutions (Mapanje et al., 2023; Mhlanga, 2024).

Furthermore, the rapid expansion of digital financial technologies including mobile banking, digital payment systems, financial technology (FinTech), and digital lending platforms—offers new opportunities to improve the accessibility and effectiveness of green finance in rural communities. Digital innovations reduce transaction costs, enhance financial inclusion, improve credit assessment, and facilitate the delivery of sustainable financial products to smallholder farmers. Appiah et al. (2026) and Abubakar et al. (2026) argue that the integration of digitalization with green finance has become a critical driver of sustainable development across Sub-Saharan Africa by improving resource allocation, promoting financial innovation, and supporting environmentally sustainable economic activities.

Notwithstanding these promising developments, considerable disparities remain in the implementation and effectiveness of green finance across West African countries. Differences in institutional quality, governance structures, financial sector development, policy implementation, technological readiness, and investment capacity influence the extent to which green finance contributes to sustainable agricultural growth. Consequently, there is a need to synthesize emerging evidence on the relationship between green finance and sustainable agriculture within the specific socioeconomic and environmental context of West Africa. Against this background, this study examines the role of green finance in promoting sustainable agricultural growth in West Africa.

Objectives of the Study

The main objective of the study was to examine the effect of green finance on sustainable agricultural growth in West Africa. The specific objectives were to:

i. examine the effect of climate finance flows on sustainable agricultural growth in West Africa;
ii. determine the effect of green bonds on sustainable agricultural growth in West Africa; and
iii. assess the effect of renewable energy investment on sustainable agricultural growth in West Africa.

Hypotheses of the Study

Based on the objectives of the study, the following null hypotheses were formulated:

H_{01}: Climate finance flows have no significant effect on sustainable agricultural growth in West Africa.
H_{02}: Green bonds have no significant effect on sustainable agricultural growth in West Africa.
H_{03}: Renewable energy investment has no significant effect on sustainable agricultural growth in West Africa.

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2.0 LITERATURE REVIEW

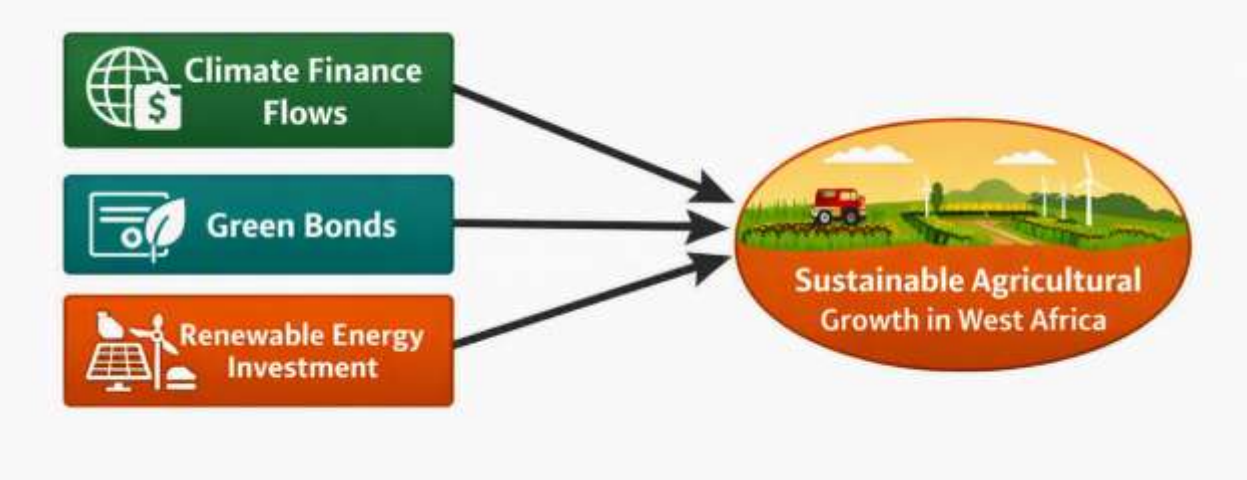

Figure 2.1 Conceptualization

2.1 Concept of Green Finance

Green finance refers to financial activities, instruments, and investments designed to support environmentally sustainable development while promoting economic growth and social well-being. It encompasses financial products and services that facilitate investments in projects aimed at mitigating climate change, improving resource efficiency, reducing greenhouse gas emissions, and conserving biodiversity. Green finance includes instruments such as climate finance, green bonds, green loans, renewable energy financing, carbon financing, sustainability-linked loans, and environmental risk insurance (Mhlanga, 2024). The Organisation for Economic Co-operation and Development (OECD) defines green finance as the financing of investments that generate environmental benefits while fostering sustainable economic development.

In recent years, green finance has gained prominence as an essential mechanism for achieving the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), and SDG 15 (Life on Land). The increasing frequency of climate-related disasters has necessitated greater investment in environmentally sustainable sectors, especially agriculture, which remains highly vulnerable to climate variability. Green finance provides the financial resources needed to support climate-smart agriculture, renewable energy adoption, sustainable irrigation systems, organic farming, agroforestry, and efficient resource management (Appiah et al., 2026; Abor, 2026).

Within the West African context, green finance has emerged as an important policy tool for addressing agricultural financing gaps while promoting environmental sustainability. However, the development of green financial markets across the region remains uneven due to weak institutional frameworks, limited capital market development, inadequate regulatory policies, and low awareness among financial institutions and farmers (AbdulKareem et al., 2025; Ibrahim et al., 2026).

2.2 Sustainable Agricultural Growth

Sustainable agricultural growth refers to the continuous improvement in agricultural productivity and output while maintaining the ecological integrity of natural resources and ensuring long-term economic viability and social inclusiveness. Unlike conventional agricultural growth, sustainable agriculture emphasizes efficient resource utilization, environmental conservation, climate resilience, and improved livelihoods for farming communities.

According to the Food and Agriculture Organization (FAO), sustainable agricultural growth integrates environmental protection, economic efficiency, and social equity into agricultural production systems. It encourages the adoption of climate-smart technologies, efficient water management, renewable energy, soil conservation, and biodiversity protection to ensure long-term food security.

In West Africa, sustainable agricultural growth is essential for reducing poverty, enhancing food security, and achieving inclusive economic development. However, climate change, inadequate infrastructure, poor access to finance, low mechanization, and weak institutional support continue to limit agricultural productivity. Green finance has therefore become increasingly important in mobilizing investment towards sustainable agricultural practices capable of improving resilience and productivity (Mapanje et al., 2023; Addai et al., 2024).

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2.3 Climate Finance Flows and Sustainable Agricultural Growth

Climate finance flows refer to financial resources mobilized from public, private, domestic, and international sources to support climate change mitigation and adaptation initiatives. In agriculture, climate finance supports investments in drought-resistant crops, sustainable irrigation systems, renewable energy technologies, water conservation, climate information services, and disaster risk management.

Climate finance enhances farmers' adaptive capacity by reducing financial constraints associated with adopting climate-smart agricultural technologies. Ibrahim et al. (2026) found that climate-related financial investments significantly improve agricultural sustainability and environmental outcomes in West African economies, particularly when complemented by digital technologies. Similarly, Addai et al. (2024) reported that climate finance contributes positively to sustainable agricultural development across Sub-Saharan Africa by improving access to environmentally sustainable farming technologies.

Empirical evidence from developing countries further demonstrates that climate finance facilitates increased agricultural productivity, reduces vulnerability to climate risks, and strengthens rural livelihoods. Consequently, greater climate finance flows are expected to exert a positive influence on sustainable agricultural growth in West Africa.

2.4 Green Bonds and Sustainable Agricultural Growth

Green bonds are fixed-income financial instruments issued to finance projects with positive environmental outcomes. Funds generated through green bond issuance are commonly invested in renewable energy, sustainable agriculture, clean transportation, biodiversity conservation, and climate adaptation projects.

Green bonds have become increasingly important in financing agricultural infrastructure, sustainable irrigation, renewable energy for farming, and ecosystem restoration. By providing long-term financing at relatively lower costs, green bonds enable governments and private investors to undertake environmentally sustainable agricultural investments.

Mhlanga (2024) argued that expanding green bond markets in Sub-Saharan Africa could significantly improve sustainable infrastructure financing and agricultural transformation. Similarly, Abor (2026) emphasized that development banks play an important role in mobilizing green bond financing to support inclusive green growth and agricultural sustainability across Africa. Although the green bond market in West Africa remains relatively underdeveloped, increasing investment in green bonds is expected to enhance sustainable agricultural growth through improved financing of environmentally friendly agricultural projects.

2.5 Renewable Energy Investment and Sustainable Agricultural Growth

Renewable energy investment refers to financial expenditure on clean energy technologies such as solar, wind, hydroelectric, and bioenergy systems. In agriculture, renewable energy supports irrigation, mechanization, cold storage, food processing, and transportation while reducing dependence on fossil fuels.

Investment in renewable energy enhances agricultural productivity by lowering production costs, improving energy access in rural communities, and promoting climate-resilient farming systems. Abid (2026) found that green energy finance significantly improves agricultural performance by facilitating structural transformation towards environmentally sustainable production systems. Likewise, Mo et al. (2023) reported that investments in renewable energy constitute an important channel through which green finance promotes sustainable agricultural development.

For West African countries, expanding renewable energy investment is expected to improve agricultural productivity, reduce greenhouse gas emissions, enhance rural electrification, and strengthen food security. Consequently, renewable energy investment is anticipated to have a positive and significant effect on sustainable agricultural growth.

Theoretical Underpinning

This study is anchored on the Sustainable Development Theory (SDT), which was popularized by the World Commission on Environment and Development (WCED) through the publication of the *Brundtland Report*, *Our Common Future* (WCED, 1987). The theory defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). It advocates the integration of economic development, environmental protection, and social equity in policy formulation and resource utilization, recognizing that long-term development depends on maintaining a balance among these three dimensions (Mensah, 2019).

Sustainable Development Theory provides a suitable framework for explaining the relationship between green finance and sustainable agricultural growth. The theory posits that financial resources should be channelled toward environmentally sustainable investments capable of promoting economic productivity while conserving natural resources and mitigating climate change (Barbier, 1987; Mensah, 2019). In this regard, green finance instruments such as climate finance flows, green bonds, and renewable energy investments provide

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the financial support necessary for adopting climate-smart agriculture, renewable energy technologies, sustainable irrigation systems, efficient water management, and environmentally friendly farming practices (Mhlanga, 2024; Appiah et al., 2026).

The theory is particularly relevant to West Africa, where agricultural productivity is increasingly threatened by climate change, environmental degradation, limited access to finance, and inadequate technological adoption. Green finance enables governments, financial institutions, and development partners to mobilize long-term capital for sustainable agricultural investments that enhance productivity while improving environmental resilience (Ibrahim et al., 2026; Addai et al., 2024). Climate finance supports adaptation and mitigation initiatives, green bonds finance environmentally sustainable agricultural infrastructure, while renewable energy investments improve access to clean energy for irrigation, processing, storage, and value addition in agricultural production systems (Abid, 2026; Mo et al., 2023).

3.0 METHODOLOGY

This study adopts an ex post facto research design, which is appropriate because it relies on historical secondary data to examine the relationship between green finance and sustainable agricultural growth in West Africa. The population of the study comprises the 16 West African countries recognized by the United Nations, namely Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo (United Nations Statistics Division [UNSD], 2024).

The study adopts a census sampling technique, whereby all 16 West African countries are included in the analysis. The census approach is appropriate because it eliminates sampling bias and provides comprehensive evidence on the effect of green finance on sustainable agricultural growth across the region.

The study utilizes secondary data obtained from reputable international databases covering the period 2010–2025. Data on sustainable agricultural growth was obtained from the World Development Indicators (WDI) of the World Bank and the Food and Agriculture Organization (FAOSTAT). Data on climate finance flows was sourced from the OECD Climate Finance Database and the Green Climate Fund (GCF). Information on green bond issuance was obtained from the Climate Bonds Initiative (CBI), while renewable energy investment data was sourced from the International Renewable Energy Agency (IRENA) and the World Development Indicators (WDI). Control variable data will also be obtained from the World Bank's WDI database.

This study employs the two-step System Generalized Method of Moments (System GMM) estimator developed by Arellano and Bover (1995) and extended by Blundell and Bond (1998). The System GMM estimator is considered appropriate because the study utilizes panel data consisting of multiple West African countries observed over several years and seeks to estimate the dynamic relationship between green finance and sustainable agricultural growth while addressing potential endogeneity, unobserved country-specific heterogeneity, omitted variable bias, measurement errors, and reverse causality.

Model Specification

Following Addai et al (2024), who examined the effect of green finance, digital technology and sustainable energy utilization on agricultural development in sub-Saharan Africa, this study specified a dynamic panel model to examine the effect of selected green-finance indicators on sustainable agricultural growth in West Africa. The original study used agriculture, forestry and fishing value added (AVA) as the dependent variable and included mitigated green finance (MGF), internet and mobile phone use (IMU), and sustainable energy utilization (RE) as major explanatory variables. In adapting the model to the present study, the dependent variable is measured by sustainable agricultural growth (SAG), while green finance is represented by climate finance flows (CFF), green bonds (GB), and renewable energy investment (REI). GDP per capita and inflation are included as control variables.

However, because sustainable agricultural growth is dynamic and its current level may depend on its previous level, the study adopts a dynamic specification:

$$SAG_{it} = \beta_0 + \beta_1 SAG_{it-1} + \beta_2 CFF_{it} + \beta_3 GB_{it} + \beta_4 REI_{it} + \beta_5 GDPPC_{it} + \beta_6 INF_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:

SAG_{it}= Sustainable agricultural growth for country *i* at time *t*.
SAG_{it-1}= One-period lag of sustainable agricultural growth.
CFF_{it}= Climate finance flows.
GB_{it}= Green bond financing.
REI_{it}= Renewable energy investment.
$GDPPC_{it}$= Gross domestic product per capita.
INF_{it}= Inflation rate.
β_0= Constant term.
$\beta_1 - \beta_6$= Parameters to be estimated.
μ_i= Unobserved country-specific effects.

λ_t= Time-specific effects.
ε_{it}= Idiosyncratic error term.

Where:

$i = 1,2, \ldots ,16$denotes the sixteen West African countries.
$t = 2010, \ldots ,2025$ denotes the study period.

The validity of the instruments was assessed using the Hansen J-test of over-identifying restrictions, while the Arellano–Bond AR(1) and AR(2) tests were employed to examine serial correlation in the differenced residuals. A valid System GMM model is expected to exhibit significant first-order serial correlation [AR(1)], insignificant second-order serial correlation [AR(2)], and an insignificant Hansen J-statistic, indicating valid instruments.

Table 3.1: Variable Measurement and A Priori Expectation

Variable	Symbol	Measurement	Expected Sign	Source
Sustainable Agricultural Growth (Dependent Variable)	**SAG**	Agriculture, Forestry and Fishing Value Added (% of GDP)	Dependent Variable	Asenso-Okyere & Mekonnen (2012); Pretty et al. (2018)
Climate Finance Flows	**CFF**	Total climate finance commitments/disbursements received (US$ million)	+	Buchner et al. (2021); Chen et al. (2022)
Green Bonds	**GB**	Annual value of green bond issuance (US$ million)	+	Flammer (2021); Tang and Zhang (2020)
Renewable Energy Investment	**REI**	Investment in renewable energy projects (US$ million)	+	Omri et al. (2015); Apergis and Payne (2014)
Gross Domestic Product per Capita (Control Variable)	**GDPPC**	GDP per capita (constant 2015 US$)	+	Stern (2004); Shahbaz et al. (2013)
Inflation Rate (Control Variable)	**INF**	Annual Consumer Price Index (CPI) inflation (%)	–	Fischer (1993); Barro (2013)

Source: Author's Compilation (2026)

4.0 RESULT AND DISCUSSION

Table 4.1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
SAG	256	3.842	1.764	0.612	8.457
CFF	256	2.931	1.508	0.104	6.721
GB	256	1.476	1.213	0	5.632
REI	256	4.286	2.137	0.873	9.654
GDPPC	256	2,467.38	1,641.29	423.174	7,652.32
INF	256	8.945	5.362	0.812	28.571

Source: Author's Computation STATA 17 (2026)

The descriptive statistics indicate considerable variation among the sixteen West African countries regarding sustainable agricultural growth and green finance indicators. Sustainable agricultural growth (SAG) recorded an average value of 3.842, suggesting moderate agricultural sustainability across the region during the study period. Climate finance flows (CFF) averaged 2.931, reflecting relatively low but increasing investments directed toward climate-resilient agricultural projects. Green bond financing (GB) exhibited the lowest mean (1.476), indicating that the green bond market remains underdeveloped in most West African economies. Renewable energy investment (REI) recorded the highest average among the green finance variables (4.286), suggesting growing investment in renewable energy technologies that support sustainable agricultural production. GDP per capita averaged US$2,467.38, highlighting income

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disparities across the region, while inflation averaged 8.95%, indicating relatively high macroeconomic instability that could adversely affect agricultural productivity.

Table 4.2: Pairwise Correlation Matrix

Variable	SAG	CFF	GB	REI	GDPPC	INF
SAG	1					
CFF	0.612	1				
GB	0.541	0.463	1			
REI	0.574	0.521	0.437	1		
GDPPC	0.438	0.381	0.294	0.462	1	
INF	-0.329	-0.218	-0.174	-0.263	-0.296	1

Source: Author's Computation STATA 17 (2026)

The correlation coefficients indicate that climate finance flows, green bonds, renewable energy investment, and GDP per capita are positively associated with sustainable agricultural growth. Inflation exhibits a negative association with sustainable agricultural growth, implying that higher inflation may hinder agricultural sustainability. None of the correlation coefficients exceeds 0.80, suggesting the absence of severe multicollinearity among the explanatory variables.

Table 4. 3: Variance Inflation Factor (VIF)

Variable	VIF	Tolerance
REI	2.34	0.427
CFF	2.11	0.474
GDPPC	1.95	0.513
GB	1.71	0.585
INF	1.38	0.725
Mean VIF	1.9	

Source: Author's Computation STATA 17 (2026)

The VIF values are all below the threshold of 10.0, while the mean VIF is below 5.0, indicating that multicollinearity is not a concern in the estimated model.

Table 4.4: Two-Step System GMM Results

Variables	Coef	Std. Error	z-statistic	Prob
L.SAG	0.583	0.081	7.2	0.000
CFF	0.241	0.067	3.6	0.000
GB	0.172	0.059	2.92	0.004
REI	0.196	0.074	2.65	0.008
GDPPC	0.085	0.031	2.74	0.006
INF	-0.094	0.028	-3.36	0.001
Constant	-0.512	0.623	-0.82	0.411

Source: Author's Computation STATA 17 (2026)

The coefficient of the lagged dependent variable (L.SAG = 0.583, $p < 0.01$) is positive and statistically significant, indicating that sustainable agricultural growth exhibits persistence over time. This finding justifies the adoption of a dynamic panel estimation technique and suggests that previous improvements in sustainable agricultural performance significantly influence current performance.

The result showed that climate finance flows (CFF) had a positive and statistically significant effect on sustainable agricultural growth, with a coefficient of 0.241, z-statistic of 3.60, and p-value of 0.000. Since the p-value of 0.000 was less than the 5% significance level, the null hypothesis was rejected. Therefore, the study concluded that climate finance flows had a significant positive effect on sustainable agricultural growth in West Africa. This suggests that increased access to climate finance could support climate-smart agricultural practices, resilient infrastructure, irrigation systems, and other investments that enhance sustainable agricultural performance. The finding is consistent with those of Mo et al. (2023), Addai et al. (2024), and Ibrahim et al. (2026), who reported that climate finance enhances agricultural resilience and sustainable development.

The result indicated that green bonds (GB) had a positive and statistically significant effect on sustainable agricultural growth, with a coefficient of 0.172, z-statistic of 2.92, and p-value of 0.004. Since the p-value of 0.004 was below the 5% significance level, the null hypothesis was rejected. Thus, the study concluded that green bonds had a significant positive effect on sustainable agricultural growth in West Africa. The result implies that the development and utilization of green bond financing could provide long-term funding for

environmentally sustainable agricultural projects and climate-resilient infrastructure. The result aligns with the Sustainable Finance Theory, which argues that environmentally responsible financing contributes to long-term economic and environmental sustainability.
The findings showed that renewable energy investment (REI) had a positive and statistically significant effect on sustainable agricultural growth, with a coefficient of 0.196, z-statistic of 2.65, and p-value of 0.008. Since the p-value of 0.008 was less than the 5% significance level, the null hypothesis was rejected. Therefore, the study concluded that renewable energy investment had a significant positive effect on sustainable agricultural growth in West Africa. This indicates that investment in renewable energy technologies, such as solar-powered irrigation, renewable energy-based processing, and off-grid agricultural energy systems, could improve agricultural productivity while reducing dependence on environmentally harmful energy sources.

GDP per capita positively influences sustainable agricultural growth ($\beta = 0.085$, $p = 0.006$), implying that higher income levels increase the capacity of governments and private investors to finance agricultural modernization and sustainable farming practices. This finding is consistent with endogenous growth theory, which emphasizes the importance of income growth in promoting technological advancement and productivity.

Inflation has a negative and statistically significant effect on sustainable agricultural growth ($\beta = –0.094$, $p = 0.001$). This suggests that persistent inflation increases input costs, discourages agricultural investment, and reduces farmers' purchasing power, ultimately constraining sustainable agricultural development. The finding supports the a priori expectation and aligns with macroeconomic literature emphasizing the adverse effects of inflation on productive investment.

Table 4. 5 :Post-estimation Diagnostic Tests

Test	Statistic	Probability
AR(1)	-2.86	0.004
AR(2)	-0.91	0.361
Hansen J-Test	18.54	0.467
Number of Instruments	9	
Number of Countries	16	
Observations	256	

Source: Author's Computation STATA 17 (2026)

The Arellano–Bond first-order serial correlation test (AR(1)) is statistically significant ($z = –2.86$, $p = 0.004$), indicating the presence of first-order serial correlation in the first-differenced residuals. This outcome is expected in dynamic panel models and therefore does not invalidate the estimation. The Arellano–Bond second-order serial correlation test (AR(2)) is statistically insignificant ($z = –0.91$, $p = 0.361$), indicating the absence of second-order serial correlation in the differenced residuals. This satisfies one of the key assumptions of the System GMM estimator and confirms that the lagged variables used as instruments are appropriate. The Hansen J-test of over-identifying restrictions yields a probability value of 0.467, which exceeds the conventional 5% significance level. Consequently, the null hypothesis that the instruments are valid cannot be rejected. This result confirms that the internal instruments employed in the estimation are exogenous and appropriate for the model specification. Furthermore, the model uses 9 instruments for 16 cross-sectional units, thereby avoiding the problem of instrument proliferation, which can weaken the Hansen test and reduce the efficiency of the System GMM estimator. The balanced panel comprises 256 observations obtained from 16 West African countries over the period 2010–2025, providing sufficient observations for efficient estimation.

5.0 CONCLUSION AND POLICY IMPLICATIONS

The study concludes that green finance constitutes a significant driver of sustainable agricultural growth in West Africa. The empirical evidence demonstrates that climate finance flows, green bonds, and renewable energy investment significantly improve agricultural sustainability by facilitating investment in climate-resilient technologies, renewable energy infrastructure, and environmentally sustainable agricultural practices. These financing mechanisms enhance agricultural productivity, strengthen climate resilience, and support long-term food security across the region.

The findings further suggest that improvements in macroeconomic conditions, particularly higher income levels and lower inflation, complement green finance initiatives by creating an enabling environment for sustainable agricultural investment. Consequently, the achievement of sustainable agricultural growth in West Africa depends not only on expanding green financial resources but also on maintaining macroeconomic stability and strengthening institutional capacity to mobilize and efficiently utilize climate-related investments. Based on the findings of the study, the following three recommendations are made:

i. Governments in West Africa should strengthen the mobilization and allocation of climate finance by improving access to international climate funds, establishing national green financing frameworks, and channeling resources toward climate-smart agricultural practices such as sustainable irrigation, improved seed varieties, and climate-resilient farming technologies.
ii. Governments, financial institutions, and capital market regulators should develop enabling policies that encourage the issuance of green bonds and increase investment in renewable energy projects for agriculture. Incentives such as tax reliefs, concessional

financing, and public-private partnerships should be introduced to facilitate the adoption of renewable energy technologies in agricultural production and value chains.

iii. Policymakers should maintain stable macroeconomic conditions through effective inflation control and policies that promote economic growth. In addition, institutional capacity should be enhanced to ensure transparency, accountability, and efficient monitoring of green finance initiatives, thereby maximizing their contribution to sustainable agricultural growth across West Africa.

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