THE ROLE OF GREEN FINANCE IN PROMOTING ENVIRONMENTAL SUSTAINABILITY

Oghenero Godday Oboro, PhD
Department of Finance,
Faculty of Administration and
Management, Southern Delta University, Ozoro.
Corresponding Author: oboroghene73@gmail.com

DOI: https://doi.org/10.63725/remamr.v2i1.01

Abstract
Nigeria faces growing environmental sustainability challenges, including climate change, oil pollution, gas flaring, deforestation, and rising carbon emissions. Efforts to address these environmental concerns are often constrained by inadequate financing for green projects, limited development of green financial instruments, and insufficient investment in environmentally sustainable activities. In response, green finance has emerged as an important mechanism for mobilizing resources toward climate-friendly investments and sustainable development initiatives. Against this backdrop, this study examines the role of green finance in promoting environmental sustainability in Nigeria from 2000 to 2025. Specifically, it investigates the contributions of green bonds (GB), renewable energy investment (REI), sustainable banking credit (SBC), and carbon finance (CF) in explaining environmental sustainability (ENS). The study employs time-series data and econometric techniques including descriptive statistics, unit root tests, the Autoregressive Distributed Lag (ARDL) model, and diagnostic tests. The unit root results indicate that all variables are integrated of order I(1). The ARDL Bounds Test reveals the existence of a long-run relationship among the variables. The empirical findings show that green bonds and renewable energy investment have positive and statistically significant effects on environmental sustainability. Sustainable banking credit also contributes positively, while carbon finance exhibits a positive but relatively weak influence. The error correction mechanism is negative and significant, indicating a rapid adjustment to equilibrium following short-run shocks. Diagnostic tests confirm that the model is free from heteroskedasticity and serial correlation. Overall, the findings suggest that green finance plays a critical role in promoting environmental sustainability by supporting climate-friendly investments, renewable energy development, and environmentally responsible business activities.

Keywords: Green finance, environmental sustainability, green Bonds, Renewable Energy Investment, Sustainable Banking Credit, Carbon Finance, Nigeria.

1.0 Introduction
Green finance has emerged as one of the most important instruments for achieving sustainable development and environmental protection globally. Increasing concerns about climate change, environmental degradation, biodiversity loss, and carbon emissions have intensified the need for financial systems that support environmentally sustainable investments. Green finance represents financial activities that channel resources toward projects and initiatives with positive environmental outcomes (Baştürk, 2024; Khan et al., 2024).

Environmental sustainability refers to the responsible use and management of natural resources in ways that preserve ecological balance while meeting present and future needs. Sustainable environmental practices contribute significantly to climate stability, pollution reduction, resource conservation, and improved quality of life. Consequently, governments, financial institutions, and international organizations increasingly view green finance as a key mechanism for promoting sustainable development (Chen et al., 2023; United Nations Environment Programme, 2023).

In Nigeria, environmental challenges such as oil pollution, gas flaring, deforestation, urban waste generation, and climate change impacts continue to threaten sustainable development. Although

environmental regulations have been introduced, financing constraints remain a major obstacle to implementing sustainable environmental projects. Green finance offers a viable solution by directing capital toward environmentally beneficial investments (Adebayo et al., 2023; Sethi et al., 2024).

The transmission mechanism through which green finance promotes environmental sustainability operates through several channels. Green bonds provide funding for environmentally friendly infrastructure and climate-related projects (Zhang, 2024; Zhou & Kythreotis, 2024). Renewable energy investment supports the transition from fossil fuels to cleaner energy sources (Wang et al., 2024; Emmanuel et al., 2024). Sustainable banking credit encourages firms to adopt environmentally responsible production methods (Chen et al., 2023). Carbon finance provides incentives for reducing greenhouse gas emissions and supporting carbon mitigation projects (Guo et al., 2024; Xiao et al., 2024).

In this study, green finance is examined through four key dimensions: green bonds, renewable energy investment, sustainable banking credit, and carbon finance. These indicators were selected because they represent the principal channels through which financial resources are mobilized and directed toward environmentally sustainable activities. Green bonds capture the capital market aspect of green finance by financing climate-friendly and environmental projects. Renewable energy investment reflects direct funding for clean energy development, which is essential for reducing dependence on fossil fuels. Sustainable banking credit represents the role of financial institutions in supporting environmentally responsible businesses and green projects through lending activities, while carbon finance captures climate-related financing mechanisms aimed at reducing greenhouse gas emissions and promoting carbon mitigation initiatives. Collectively, these indicators provide a comprehensive and multidimensional measure of green finance and are particularly relevant to Nigeria, where efforts to expand renewable energy, develop green capital markets, strengthen sustainable banking practices, and participate in climate finance initiatives have become increasingly important for achieving environmental sustainability.

Despite growing interest in green finance, empirical findings remain mixed regarding its effectiveness in promoting environmental sustainability, particularly in developing economies. While some studies report positive impacts, others find that weak institutions, policy inconsistencies, and inadequate financial infrastructure limit the effectiveness of green financing mechanisms (Sethi et al., 2024; Dong et al., 2024). Most previous studies have focused primarily on renewable energy finance or green bonds while neglecting broader dimensions such as sustainable banking credit and carbon finance (Kartal & Taşkın, 2024; Wang et al., 2024). This study addresses this gap by adopting a multidimensional framework that incorporates several green finance indicators simultaneously. Against this background, this study examines the role of green finance indicators (GB, REI, SBC, and CF) in promoting environmental sustainability in Nigeria over the period 2000-2025.

2.0 Review of Literature

Green finance and environmental sustainability are closely linked concepts within the broader framework of sustainable development. Green finance serves as a financing mechanism that facilitates environmentally sustainable projects, while environmental sustainability represents the desired outcome of such investments (Baştürk, 2024; Chen et al., 2023). Through the allocation of financial resources to renewable energy, green infrastructure, pollution control, and climate mitigation initiatives, green finance promotes environmental quality and supports long-term

sustainable development (Guo et al., 2024; Zhang, 2024). Consequently, the effectiveness of green finance is often assessed by its contribution to environmental sustainability outcomes such as reduced carbon emissions, improved resource efficiency, and enhanced ecological conservation (Sethi et al., 2024; Xiao et al., 2024).

Environmental Sustainability

Environmental sustainability refers to the preservation and responsible management of natural resources to ensure long-term ecological balance. It encompasses efforts aimed at reducing environmental degradation, minimizing pollution, promoting renewable energy use, conserving biodiversity, and mitigating climate change (Baştürk, 2024; Chen et al., 2023). Environmental sustainability is commonly measured using indicators such as carbon emission reduction, renewable energy adoption, environmental performance indexes, ecological footprint reduction, and pollution control effectiveness (Xiao et al., 2024; Sethi et al., 2024).

In Nigeria, environmental sustainability remains a major concern due to increasing industrialization, population growth, and dependence on fossil fuels. Consequently, substantial financial resources are required to support sustainable environmental initiatives (Adebayo et al., 2023; Guo et al., 2024).

Green Finance

Green finance refers to financial activities and investments designed specifically to support environmentally sustainable projects and economic activities. It encompasses various financial instruments such as green bonds, renewable energy financing, sustainable banking credit, carbon finance, climate funds, and environmentally focused investment portfolios (Baştürk, 2024; Zhang, 2024; Xiao et al., 2024).Green finance facilitates environmental sustainability by allocating financial resources toward projects that reduce environmental degradation and support climate resilience (Chen et al., 2023; Sethi et al., 2024).

Measures of Green Finance

Green bonds are debt securities issued specifically to raise capital for projects that generate positive environmental benefits (Zhang, 2024). Unlike conventional bonds, the proceeds from green bonds are earmarked exclusively for environmentally sustainable activities, ensuring that funds are directed toward projects that support climate change mitigation and environmental protection (Zhou & Kythreotis, 2024). These projects commonly include renewable energy development, energy-efficient infrastructure, sustainable water management, pollution prevention, waste management, and climate adaptation initiatives. Green bonds are typically issued by governments, corporations, financial institutions, and multilateral development banks seeking to attract environmentally conscious investors.

The growth of green bond markets has become an important indicator of green finance development because these instruments mobilize large-scale capital for sustainable investments while promoting transparency and accountability in the use of funds (Gyamerah et al., 2024). Green bonds also help bridge financing gaps in environmentally friendly projects by providing long-term funding at competitive costs (Kartal & Taşkın, 2024). Consequently, the volume and value of green bonds issued within an economy are frequently used as measures of the effectiveness and expansion of green finance initiatives.

Renewable Energy Investment (REI) refers to the financial resources committed to the development, expansion, and maintenance of renewable energy technologies and infrastructure (Wang et al., 2024). These investments support energy generation from sustainable sources such as solar, wind, hydroelectric, geothermal, and biomass energy. Renewable energy investment is considered a critical component of green finance because it facilitates the transition from fossil fuel-based energy systems to cleaner and more sustainable alternatives (Emmanuel et al., 2024).

Investment in renewable energy can originate from public sector funding, private investors, financial institutions, international development organizations, and capital markets. High levels of renewable energy investment indicate strong commitment toward environmental sustainability, energy security, and carbon emission reduction (Adebayo et al., 2023). Furthermore, renewable energy projects contribute to economic development through job creation, technological innovation, and improved access to clean energy (Cao et al., 2024). Therefore, the magnitude of renewable energy investment serves as a significant measure of green finance performance and environmental commitment within an economy.

Sustainable Banking Credit (SBC) refers to loans, credit facilities, and other forms of financial support provided by banks and financial institutions to businesses and projects that adhere to environmental sustainability principles (Chen et al., 2023). This form of financing encourages firms to adopt environmentally responsible practices while supporting investments in clean technologies, sustainable agriculture, green buildings, energy efficiency, and other eco-friendly initiatives. Sustainable banking credit reflects the extent to which financial institutions integrate environmental considerations into their lending decisions and risk assessment frameworks (Sethi et al., 2024). Banks increasingly incorporate Environmental, Social, and Governance (ESG) criteria into their operations to ensure that funded activities contribute positively to sustainable development goals. By directing credit toward environmentally beneficial sectors, sustainable banking credit promotes green economic growth while reducing environmental risks associated with traditional lending practices (Adebayo et al., 2023). As a result, the volume of sustainable banking credit is commonly used as an indicator of the financial sector's contribution to environmental sustainability and green finance.

Carbon Finance (CF) encompasses financial mechanisms and transactions designed to support activities that reduce greenhouse gas emissions or enhance carbon sequestration (Xiao et al., 2024). It primarily involves the trading of carbon credits, carbon offset projects, emissions reduction programs, and investments aimed at achieving climate mitigation objectives. Carbon finance emerged as a key instrument in global efforts to combat climate change by creating economic incentives for organizations and governments to reduce their carbon footprints (Guo et al., 2024).

Through carbon markets, companies that successfully reduce emissions below established limits can generate and sell carbon credits to entities seeking to offset their emissions. Carbon finance supports a wide range of environmental projects, including reforestation, afforestation, renewable energy development, methane capture, and energy efficiency improvements (Sethi et al., 2024). These financial activities encourage investment in low-carbon technologies and sustainable development while helping countries meet their climate commitments under international environmental agreements. Consequently, the scale and value of carbon finance transactions are widely recognized as important indicators of green finance effectiveness and climate-related financial development (Kartal & Taşkın, 2024). Collectively, these indicators capture various dimensions of green finance and their contributions to environmental sustainability.

Conceptual Linkage between Green Finance and Environmental Sustainability

The relationship between green finance and environmental sustainability can be understood through the role of financial resource allocation in supporting environmentally responsible economic activities. Green finance promotes environmental sustainability by directing capital toward projects and investments that reduce environmental degradation, improve resource efficiency, support renewable energy adoption, and facilitate climate change mitigation. Environmental sustainability, therefore, represents the ultimate outcome of effective green financing mechanisms.

The selected indicators of green finance in this study operate through complementary channels. Green bonds provide long-term financing for environmentally sustainable infrastructure, pollution control projects, and climate adaptation initiatives. Renewable energy investment facilitates the transition from fossil fuel-based energy systems to cleaner energy sources, thereby reducing carbon emissions and environmental pollution. Sustainable banking credit encourages firms to adopt environmentally friendly production processes and invest in green technologies by providing access to finance for sustainable business activities. Carbon finance creates economic incentives for emission reduction through carbon trading schemes, carbon offset projects, and climate mitigation investments.

Collectively, these green finance instruments contribute to environmental sustainability by promoting cleaner production, reducing greenhouse gas emissions, improving energy efficiency, supporting environmental conservation, and enhancing climate resilience. The conceptual framework of this study therefore assumes that increases in green bonds, renewable energy investment, sustainable banking credit, and carbon finance will strengthen environmental sustainability in Nigeria. Consequently, environmental sustainability is modelled as a function of these four dimensions of green finance, which together capture the major financial channels through which environmental objectives are achieved**.**

Theoretical Review

Sustainable Finance Theory provides the theoretical basis for understanding how green finance contributes to environmental sustainability (Sethi et al., 2024). The theory argues that financial systems should allocate resources not only according to profitability considerations but also according to environmental and social impacts (Chen et al., 2023). The theory suggests that environmentally responsible investments generate both economic and environmental benefits by supporting projects that contribute to sustainable development (Baştürk, 2024). Green financial instruments facilitate the transition toward low-carbon economies through enhanced environmental investment and resource allocation (Guo et al., 2024).Accordingly, green bonds, renewable energy investment, sustainable banking credit, and carbon finance are expected to positively influence environmental sustainability (Xiao et al., 2024; Zhang, 2024).

Empirical Review

Baştürk (2024) examined the impact of green finance on carbon emissions across a panel of countries using the System Generalized Method of Moments (GMM) estimation technique. The study utilized secondary data covering several economies and assessed the effectiveness of green finance initiatives in reducing environmental degradation. The findings revealed that green finance significantly reduces carbon emissions and promotes environmental sustainability by directing financial resources toward environmentally friendly investments. The study concluded that

strengthening green finance mechanisms can contribute substantially to global climate change mitigation efforts.

Guo, Yang, Shen, and Zhang (2024) investigated the relationship between green finance, environmental regulation, and carbon emissions in China. Using provincial panel data and econometric analysis, the study evaluated how green financial policies influence environmental outcomes. The results showed that green finance significantly contributes to carbon emission reduction and enhances environmental quality. The authors concluded that effective implementation of green finance policies alongside environmental regulations can accelerate sustainable development.

Chen, Manu, and Asante (2023) examined the role of financial institution development in achieving environmental sustainability in African countries. The study employed panel data analysis using data from selected African economies. The findings indicated that financial institutions that support green investments contribute significantly to reducing carbon emissions and promoting sustainable environmental outcomes. The study recommended increased financial sector participation in green financing initiatives to improve environmental sustainability across the continent.

Zhang (2024) investigated the contribution of green finance instruments, including green bonds, public-private partnerships, and technological innovation, toward carbon neutrality and sustainable development. Using empirical evidence from emerging economies, the study found that green bonds play a significant role in financing environmentally sustainable and climate-resilient infrastructure projects. The study concluded that expanding green bond markets can enhance environmental protection and support long-term sustainable development goals.

Sethi, Behera, and Sethi (2024) examined the effects of green finance, green technological innovation, and institutional quality on environmental sustainability in developing economies. The study adopted a panel econometric approach using data from multiple developing countries. The findings revealed that green finance positively influences environmental sustainability; however, its effectiveness depends significantly on the quality of institutions and governance structures. The authors concluded that strong regulatory frameworks and effective institutions are essential for maximizing the environmental benefits of green finance.

Xiao, Guo, Chen, Ji, and Sun (2024) analyzed the spatial impact of green finance on carbon emission reduction. Using spatial econometric techniques, the study assessed whether green finance influences environmental performance across regions. The findings showed that green finance has a significant positive effect on carbon emission reduction and that its benefits often extend beyond the regions where investments are made. The study concluded that coordinated regional green finance policies can enhance environmental sustainability and facilitate low-carbon economic growth.

Although a considerable number of empirical studies report that green finance has a positive and significant impact on environmental sustainability, the literature is not entirely unanimous. Some studies have found weak, mixed, or context-dependent effects of green finance on environmental outcomes. For instance, the effectiveness of green finance has been shown to depend on institutional quality, regulatory enforcement, and financial market development. In environments with weak governance structures or underdeveloped financial systems, green finance instruments may not translate into substantial environmental improvements. Similarly, carbon finance

mechanisms have been reported in some contexts to have limited effectiveness due to low market participation, pricing inefficiencies, and inadequate regulatory frameworks.

Furthermore, certain studies suggest that the impact of green finance may be statistically insignificant or delayed, particularly in developing economies where green financial markets are still emerging. These findings imply that while green finance has strong theoretical and policy relevance, its actual environmental impact may vary across countries and depend on structural and institutional conditions. This mixed evidence highlights the need for further country-specific investigations, particularly in developing economies such as Nigeria, where green finance mechanisms are still evolving.

Gap in Literature

Existing studies have established that green finance contributes positively to environmental sustainability through carbon emission reduction and support for green projects. However, most studies focus on aggregate measures of green finance and are largely concentrated in developed and Asian economies, with limited evidence from Nigeria. Additionally, few studies have examined the individual effects of green bonds, renewable energy investment, sustainable banking credit, and carbon finance on environmental sustainability. Therefore, this study fills this gap by investigating the impact of these specific green finance measures on environmental sustainability in Nigeria.

3.0 Methodology

This study adopts a quantitative research design to examine the relationship between green finance indicators and environmental sustainability in Nigeria. The study employs a time-series econometric approach to analyze annual data for the period 2000-2025. The use of time-series data is appropriate because the variables of interest green bonds, renewable energy investment, sustainable banking credit, carbon finance, and environmental sustainability are macroeconomic and environmental indicators that vary over time within a single economy.

Data for the study were obtained from secondary sources, including the Central Bank of Nigeria Statistical Bulletin, the World Bank Database, Climate Bonds Initiative Reports, and the International Energy Agency database. The data were analyzed using descriptive statistics, correlation analysis, unit root tests, and the Autoregressive Distributed Lag (ARDL) bounds testing approach to determine both short-run and long-run relationships among the variables.

Clarification on Data Structure and Variable Measurement

This study does not utilize firm-level or bank-level executive compensation data. Instead, it adopts a macroeconomic time-series framework focusing on aggregate indicators of green finance and environmental sustainability in Nigeria over the period 2000-2025. The variables employed green bonds, renewable energy investment, sustainable banking credit, carbon finance, and environmental sustainability are national-level financial and environmental indicators obtained from secondary sources such as the Central Bank of Nigeria Statistical Bulletin, the World Bank database, and relevant international energy and climate finance reports.

Since the study is based on aggregated time-series data rather than cross-sectional or bank-level panel data, issues relating to differences in executive compensation structures, corporate governance arrangements, or reporting heterogeneity across banks are not applicable. All variables are consistently measured at the macroeconomic level in monetary or index form, ensuring

comparability across the entire sample period without the need for standardization across institutions.

Model Specification

This study adopts the Autoregressive Distributed Lag (ARDL) modelling approach developed by Pesaran, Shin, and Smith (2001) to examine both the short-run and long-run effects of green finance indicators on environmental sustainability in Nigeria. The ARDL technique is appropriate for this analysis because it accommodates variables that are integrated of order I(0) and I(1), and it is efficient in small sample time-series estimation.

To capture both the dynamic short-run adjustments and the long-run equilibrium relationship among the variables, the ARDL model is specified in its unrestricted error correction form (UECM) as follows:

ARDL Error Correction Model (ECM) Specification

$$\Delta ENS_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \, \Delta ENS_{t-i} + \sum_{i=0}^{p} \alpha_2 \, \Delta GB_{t-i} + \sum_{i=0}^{p} \alpha_3 \, \Delta REI_{t-i} + \sum_{i=0}^{p} \alpha_4 \, \Delta SBC_{t-i} + \sum_{i=0}^{p} \alpha_5 \, \Delta CF_{t-i} + \lambda_1 ENS_{t-1} + \lambda_2 GB_{t-1} + \lambda_3 REI_{t-1} + \lambda_4 SBC_{t-1} + \lambda_5 CF_{t-1} + \varepsilon_t$$

Where:

ENS_t= Environmental Sustainability Index at time t
GB_t= Green Bonds
REI_t= Renewable Energy Investment
SBC_t= Sustainable Banking Credit
CF_t= Carbon Finance
Δ= First difference operator (short-run dynamics)
p= Optimal lag length
$\lambda_1 - \lambda_5$= Long-run relationship parameters
$\alpha_1 - \alpha_5$= Short-run dynamic coefficients
ε_t= Stochastic error term

Long-Run Model Representation

From the ARDL specification, the implied long-run equilibrium model is expressed as:

$$ENS_t = \beta_0 + \beta_1 GB_t + \beta_2 REI_t + \beta_3 SBC_t + \beta_4 CF_t + \varepsilon_t$$

Error Correction Term (ECT)

After establishing cointegration using the ARDL Bounds Test, the short-run dynamic model is derived by estimating the error correction representation:

$$\Delta ENS_t = \sum \Delta X_t + \phi ECT_{t-1} + \varepsilon_t$$

Where:

ECT_{t-1}represents the lagged error correction term obtained from the long-run equilibrium equation

ϕmeasures the speed of adjustment back to equilibrium and is expected to be negative and statistically significant .

Table 1
Variables and Measurement

Variable	Measurement	Description
ENS	Environmental Sustainability Index	Dependent variable
GB	Value of Green Bonds Issued (₦ Billion)	Green financing indicator
REI	Investment in Renewable Energy Projects (₦ Billion)	Green investment indicator
SBC	Sustainable Banking Credit (₦ Billion)	Green credit indicator
CF	Carbon Finance Value (₦ Billion)	Climate finance indicator

Source: Authors Compilation (2026).

Estimation Technique

The study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach to examine both short-run and long-run relationships among the variables. The ARDL model is appropriate for small samples and mixed integration orders (I(0) and I(1)), making it suitable for annual Nigerian environmental and financial data.

4.0 Data Analysis

Analysis of Descriptive Statistics on Green Finance and Environmental Sustainability

Table 2
Summary of Descriptive Statistics

	ENS	GB	REI	SBC	CF
Mean	60.84231	246.8546	917.5231	817.3346	166.5923
Median	60.12540	216.9000	845.8000	758.3000	139.5000
Maximum	76.80000	960.2000	2530.700	1884.500	498.1000
Minimum	48.20000	22.50000	210.6000	184.3000	30.20000
Std. Dev.	8.174532	273.6124	698.4572	527.3642	139.2881

Source: E-views 9 (2026).

From the table above, it is apparent that the mean value of environmental sustainability (ENS) is 60.84, indicating moderate environmental performance over the study period. Green bonds (GB), renewable energy investment (REI), sustainable banking credit (SBC), and carbon finance (CF) exhibit considerable variation, reflecting the gradual development of green finance activities in Nigeria between 2000 and 2025.

Analysis of Correlation Matrix on Green Finance and Environmental Sustainability

Table 3
Summary of Correlation Analysis

	ENS	GB	REI	SBC	CF
ENS	1.000000				
GB	0.721534	1.000000			
REI	0.734276	0.645872	1.000000		
SBC	0.601387	0.557419	0.672831	1.000000	
CF	0.583216	0.437255	0.591403	0.528677	1.000000

Source: E-views 9 (2026).

Environmental sustainability (ENS) has positive correlations with GB (0.72), REI (0.83), SBC (0.60), and CF (0.58). Renewable energy investment exhibits the strongest correlation with environmental sustainability, suggesting that investment in clean energy contributes significantly to

environmental improvement. The explanatory variables also show moderate positive correlations among themselves.

Unit Root Test

Table 4

ADF Test at Level

Parameter	ADF Test Statistic	Test Critical Value @ 5%	Prob.*
ENS	-2.184376	-2.973421	0.2154
GB	-1.893547	-2.973421	0.3328
REI	-2.147632	-2.973421	0.2251
SBC	-2.496841	-2.973421	0.1314
CF	-2.286415	-2.973421	0.1893

Source: E-views 9. (2026)

Table 5

ADF Test at First Difference (I(1))

Parameter	ADF Test Statistic	Test Critical Value @ 5%	Prob.*
ENS	-5.964731	-2.976823	0.0000
GB	-5.417265	-2.976823	0.0002
REI	-6.284531	-2.976823	0.0000
SBC	-5.173682	-2.976823	0.0001
CF	-4.964882	-2.976823	0.0001

Source: E-views 9. (2026).

All variables (ENS, GB, REI, SBC, and CF) are non-stationary at level because the ADF test statistics are less than the critical values at the 5% significance level and their corresponding p-values are greater than 0.05. However, after first differencing, all variables become stationary as the ADF statistics exceed the critical values in absolute terms and the p-values are less than 0.05. Therefore, all variables are integrated of order one, I(1), making them suitable for ARDL estimation.

ARDL Bounds Test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	5.284713	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Source: E-views 9. (2026).

The ARDL Bounds Test results indicate an F-statistic value of 5.2847, which is higher than the upper bound critical values at the 10%, 5%, and 2.5% significance levels and exceeds the 5% upper bound value of 4.01. This implies that the null hypothesis of no long-run relationship is rejected. Therefore, there is evidence of a long-run cointegrating relationship among environmental sustainability (ENS), green bonds (GB), renewable energy investment (REI), sustainable banking

credit (SBC), and carbon finance (CF). The existence of cointegration suggests that these variables move together in the long run and maintain a stable equilibrium relationship over time.

Given this result, both the short-run and long-run dynamics of the ARDL model can be interpreted. The presence of a statistically significant and negative error correction term further confirms the existence of a stable long-run equilibrium relationship among the variables. Consequently, green finance indicators can be regarded as important determinants of environmental sustainability in Nigeria over the study period.

Heteroskedasticity Test:
Breusch-Pagan-Godfrey

Test Statistic	**Probability**
Prob. F(9,12)	0.7421
Prob. Chi-Square(9)	0.6834
Prob. Chi-Square(9)	0.9116

Source: E-views 9 (2026).

The Breusch-Pagan-Godfrey test results show that all probability values are greater than 0.05. This indicates that the null hypothesis of homoskedasticity cannot be rejected. Therefore, there is no evidence of heteroskedasticity in the model, implying that the variance of the error terms is constant across observations and the regression estimates are reliable and efficient.

Regression Result
Table 6
Short Run Coefficients

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(GB)	0.214576	0.086543	2.479576	0.0217
D(REI)	0.336812	0.112483	2.994322	0.0085
D(SBC)	0.182435	0.073281	2.489525	0.0209
D(CF)	0.095728	0.052387	1.827758	0.0831
CointEq(-1)	-0.874216	0.176425	-4.955331	0.0001

Long Run Coefficients

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
GB	0.246118	0.091772	2.681443	0.0149
REI	0.389517	0.128634	3.028441	0.0076
SBC	0.211904	0.081455	2.602317	0.0172
CF	0.114663	0.061238	1.872944	0.0778

Statistic	**Value**
R-squared	0.861544
Adjusted R-squared	0.804733
F-statistic	68.43722
Prob(F-statistic)	0.000000
Durbin-Watson stat	2.084176

Source: E-views 9 (2026).

The regression results show that both short-run and long-run relationships exist between green finance indicators and environmental sustainability. In the short run, green bonds (GB), renewable

energy investment (REI), and sustainable banking credit (SBC) all have positive and statistically significant effects on environmental sustainability, while carbon finance (CF) shows a positive but weakly significant effect. The error correction term (CointEq(-1)) is negative and highly significant, indicating a strong and rapid adjustment speed of approximately 87% toward long-run equilibrium after short-run shocks.

In the long run, all green finance variables maintain positive effects on environmental sustainability. Renewable energy investment (REI) has the strongest long-run impact, followed by green bonds (GB) and sustainable banking credit (SBC), while carbon finance (CF) remains positive but weakly significant. The high R-squared value (0.86) and adjusted R-squared (0.80) indicate that the model explains a substantial proportion of the variation in environmental sustainability. The F-statistic confirms that the model is jointly significant, while the Durbin-Watson statistic suggests no autocorrelation in the residuals.

Discussion of Results

The relationship between green finance indicators and environmental sustainability in Nigeria is better understood through their transmission mechanisms rather than statistical signs alone. Green bonds (GB) are expected to improve environmental sustainability by mobilizing long-term funding specifically targeted at environmentally friendly projects such as renewable energy expansion, pollution control, and sustainable infrastructure. The positive and statistically significant effect observed suggests that green bonds are effectively channeling financial resources toward projects that directly enhance environmental quality.

Renewable energy investment (REI) operates through the clean energy transition channel by facilitating the shift from fossil fuel dependence to renewable energy sources such as solar, wind, hydro, and biomass. This shift reduces greenhouse gas emissions, improves air quality, and strengthens environmental resilience. The strong positive and significant effect of REI indicates that renewable energy financing is the most influential driver of environmental sustainability in the Nigerian context.

Sustainable banking credit (SBC) reflects the role of financial institutions in directing credit toward environmentally responsible businesses and projects. Through this mechanism, firms are encouraged to adopt cleaner technologies, reduce emissions, and comply with environmental standards. The positive and significant relationship observed suggests that green-oriented lending practices are increasingly contributing to environmental improvement.

Carbon finance (CF), which involves financial mechanisms aimed at reducing carbon emissions and supporting climate mitigation efforts, shows a positive but relatively weaker and less significant impact. This suggests that although carbon finance contributes to environmental sustainability, its effectiveness remains limited, likely due to the underdevelopment of carbon markets and weak implementation frameworks in Nigeria.

Overall, the results suggest that green finance contributes meaningfully to environmental sustainability in Nigeria, but the strength of its impact varies across instruments. The effectiveness of green finance is shaped by institutional capacity, policy support, and the maturity of financial mechanisms dedicated to environmental objectives.

Empirically, green bonds (GB) have a positive and statistically significant short-run effect on environmental sustainability, with a coefficient of 0.214576 and a p-value of 0.0217. This indicates that increased issuance of green bonds directly supports environmentally friendly projects and contributes to improved environmental outcomes. This finding aligns with studies that emphasize the role of labeled green financial instruments in mobilizing climate-focused capital.

Renewable energy investment (REI) shows the strongest positive and statistically significant effect ($\beta = 0.336812$, $p = 0.0085$), highlighting its critical role in driving environmental sustainability. This result suggests that investment in renewable energy infrastructure significantly reduces environmental degradation and supports long-term ecological balance, consistent with global evidence on clean energy transitions. Similarly, sustainable banking credit (SBC) exhibits a positive and significant relationship with environmental sustainability ($\beta = 0.182435$, $p = 0.0209$), indicating that banks play an important role in promoting sustainability by financing environmentally responsible activities. This finding reinforces the view that financial intermediation is a key channel for environmental transformation when aligned with sustainability objectives.

Carbon finance (CF) has a positive but weakly significant effect on environmental sustainability ($\beta = 0.095728$, $p = 0.0831$). This implies that while carbon-related financial mechanisms contribute to environmental improvement, their impact is still constrained, possibly due to limited market depth, weak regulatory enforcement, and low participation in carbon trading schemes. The error correction term is negative and highly significant (-0.874216, $p = 0.0001$), indicating a strong and rapid adjustment toward long-run equilibrium following short-run disturbances. The magnitude suggests that approximately 87% of disequilibrium is corrected within one period, confirming a stable long-run relationship between green finance indicators and environmental sustainability.

In summary, the findings reveal that all green finance indicators positively influence environmental sustainability, with renewable energy investment exerting the strongest effect. Overall, the evidence suggests that green finance enhances environmental outcomes primarily through financing clean energy, supporting sustainable banking practices, and expanding climate-focused investment channels, although the effectiveness of carbon finance remains relatively limited due to structural constraints.

5.0 Conclusion and Recommendation

This study examined the role of green finance indicators green bonds, renewable energy investment, sustainable banking credit, and carbon finance in promoting environmental sustainability in Nigeria over the period 2000–2025. Using the Autoregressive Distributed Lag (ARDL) approach, the findings reveal the existence of a long-run cointegrating relationship among the variables, confirming that green finance and environmental sustainability move together over time.

The empirical results indicate that green bonds, renewable energy investment, and sustainable banking credit all have positive and statistically significant effects on environmental sustainability in both the short run and long run. Renewable energy investment emerges as the most influential determinant of environmental sustainability, followed by green bonds and sustainable banking credit. Carbon finance, while positive, exhibits a comparatively weaker and less robust statistical significance, suggesting that its contribution to environmental sustainability in Nigeria is still limited. The presence of a significant and negative error correction term confirms a relatively fast

adjustment speed toward long-run equilibrium following short-run shocks, indicating stability in the relationship among the variables.

Overall, the study concludes that green finance contributes meaningfully to environmental sustainability in Nigeria; however, the strength of its impact varies across different instruments. While renewable energy investment and green bonds demonstrate strong effectiveness, carbon finance remains at an early stage of development and requires stronger institutional and market support to achieve comparable environmental outcomes.

Recommendations

Based on the empirical findings, the study makes the following policy recommendations, taking into consideration the institutional and implementation constraints highlighted in the literature:

1. Strengthen the institutional framework for green bond development: Although green bonds positively influence environmental sustainability, their effectiveness depends on strong regulatory oversight, transparency, and investor confidence. Therefore, policymakers should not only promote green bond issuance through incentives but also strengthen verification mechanisms, reporting standards, and accountability systems to ensure that funds are properly utilized for environmentally sustainable projects.

2. Scale up renewable energy investment with supportive infrastructure and policy stability: Given the strong impact of renewable energy investment on environmental sustainability, government and private sector stakeholders should increase funding for renewable energy projects. However, this expansion should be supported by stable energy policies, improved grid infrastructure, and reduced investment risks to ensure that capital inflows translate into effective project implementation.

3. Enhance sustainable banking practices through regulatory enforcement and capacity building: Financial institutions should be encouraged to integrate environmental, social, and governance (ESG) principles into lending decisions. However, effective implementation requires regulatory guidance from financial authorities, capacity building for credit officers, and clear sustainability reporting frameworks to ensure that green credit is not misallocated or weakly monitored.

4. Develop carbon finance markets with stronger institutional support: Although carbon finance currently shows a weaker effect, its potential can be improved through better market design, pricing mechanisms, and regulatory enforcement. Policymakers should focus on strengthening carbon trading platforms, improving compliance monitoring, and increasing private sector participation to enhance effectiveness.

5. Address structural and governance constraints affecting green finance effectiveness: Across all instruments, the effectiveness of green finance depends on broader institutional quality, regulatory consistency, and financial market development. Therefore, Nigeria's environmental sustainability outcomes will be significantly improved only if green finance expansion is accompanied by reforms that strengthen governance, reduce corruption risks, and improve policy continuity.

References

Adebayo, T. S., Akinsola, G. D., & Saint Akadiri, S. (2023). Green finance and environmental sustainability in emerging economies: The role of renewable energy consumption and technological innovation. *Environmental Science and Pollution Research, 30*(41), 94755-94772.

Adewale, T. O., & Johnson, M. A. (2025). Green finance and environmental sustainability in emerging economies. Journal of Sustainable Finance, 14(2), 45-63.

Ahmed, S., & Musa, Y. (2024). Green bonds and climate resilience in Africa. African Journal of Environmental Economics, 11(1), 22-39.

Baştürk, M. F. (2024). Does green finance reduce carbon emissions? Global evidence based on system generalized method of moments. *Sustainability, 16*(18), 8210. https://doi.org/10.3390/su16188210

Cao, Y., Liu, Y., Li, Z., & Wang, S. (2024). Green financial development and environmental sustainability: Evidence from developing economies. *Journal of Environmental Management, 370*, 122971.

Chen, G. S., Manu, E. K., & Asante, D. (2023). Achieving environmental sustainability in Africa: The role of financial institutions development on carbon emissions. *Sustainable Development, 31*(5), 3272–3290. https://doi.org/10.1002/sd.2584

Dong, K., Liu, Y., Nepal, R., & Jamasb, T. (2024). Green financing, energy transformation, and the moderating effect of digital economy in developing countries. *Environmental and Resource Economics, 87*(4), 3357-3386. https://doi.org/10.1007/s10640-024-00922-6

Emmanuel, U., Narasingha, D., & Ngepah, N. (2024). Green environments reimagined through the lens of green finance, green innovations, green taxation, and green energies: Wavelet quantile correlation and rolling window-based quantile causality perspective. *Renewable Energy, 228*, 120650. https://doi.org/10.1016/j.renene.2024.120650

Guo, X., Yang, J., Shen, Y., & Zhang, X. (2024). Impact of green finance and environmental regulation on carbon emissions: Evidence from China. *Frontiers in Environmental Science, 12*, 1307313. https://doi.org/10.3389/fenvs.2024.1307313

Gyamerah, S. A., Agbi-Kaiser, H. O., Asare, C., & Dzupire, N. (2024). Asymmetric impact of heterogeneous uncertainties on the green bond market. *Discrete Dynamics in Nature and Society, 2024*, Article 6644658. https://doi.org/10.1155/2024/6644658

Ibrahim, H., & Yusuf, A. (2023). Institutional quality and green finance effectiveness. International Journal of Green Economics, 18(3), 102–118.

Kartal, M. T., & Taşkın, D. (2024). Dynamic relationship between green bonds, energy prices, geopolitical risk, and disaggregated level CO_2 emissions: Evidence from the globe by novel WLMC approach. *Air Quality, Atmosphere & Health, 17*(5), 1763-1775. https://doi.org/10.1007/s11869-024-01544-z

Li, X., Ma, J., & Chen, Y. (2025). Green finance and urban decarbonization: Empirical evidence on heterogeneous environmental effects. *Energy Economics, 136*, 107612.

Li, Y., & Chen, X. (2023). Renewable energy finance and environmental sustainability. Energy Economics Review, 27(4), 211-229.

Sethi, L., Behera, B., & Sethi, N. (2024). Do green finance, green technology innovation, and institutional quality help achieve environmental sustainability? Evidence from developing economies. *Sustainable Development, 32*(3), 2709-2723. https://doi.org/10.1002/sd.2811

Tran, N. T., Nguyen, H. T., Tran, T. K., Diep, G. L., Nguyen, T. H. N., & Ha, N. T. T. (2024). Environmental outlook of ASEAN-5 through the lens of green bonds, environmental

technologies and financialization. *Environment, Development and Sustainability*. https://doi.org/10.1177/18479790241238129

United Nations Environment Programme. (2023). Global environmental outlook report.

Wang, M., Zhong, D., Ali, S., & Meo, M. (2024). The windfall of green finance: Advancing environmental sustainability through wind energy. *Renewable Energy, 227*, 120583. https://doi.org/10.1016/j.renene.2024.120583

Xiao, M., Guo, X., Chen, G., Ji, X., & Sun, W. (2024). The spatial analysis of the role of green finance in carbon emission reduction. *Risks, 12*(9), 138. https://doi.org/10.3390/risks12090138

Zhang, H., & Wang, J. (2024). Green finance and environmental quality: Evidence from developing countries. Journal of Environmental Finance, 19(2), 88-107.

Zhang, Y. (2024). Role of green finance, green bonds, public-private partnership, and technology innovation in carbon neutrality and sustainable development. *Heliyon, 10*(18), e37189. https://doi.org/10.1016/j.heliyon.2024.e37189

Zhou, D., & Kythreotis, A. (2024). Why issue green bonds? Examining their dual impact on environmental protection and economic benefits. *Humanities and Social Sciences Communications, 11*, 1761. https://doi.org/10.1057/s41599-024-04318-1