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RESEARCH ARTICLE

Green Finance and Environmental Sustainability in Nigeria: Evaluating the Role of Carbon Finance, Green Credit, and Green Securities

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ABSTRACT

Nigeria's economic development is closely tied to environmental sustainability, with green finance playing a crucial role. This study examines the impact of green financing on Nigeria's environmental sustainability by assessing the effects of carbon finance, green credit, and green securities. Using quantitative data from the Central Bank of Nigeria (CBN) statistical bulletin from 2009 to 2023, the analysis employs descriptive and inferential statistical techniques, including unit root tests, co-integration tests, panel cointegration, and panel cointegration regression estimation. A dynamic fixed effect model is used to measure impact, revealing coefficients of -0.0367631, -0.002511, and 0.0265807 for CO2F, GRL, and EPH, respectively, in the REM model for CO2E. The regression model is represented as CO2E = -0.0857249 - 0.0367631(CO2F) - 0.002511(GRL) + 0.0265807(EPH). The findings indicate that while CO2F and GRL negatively affect CO2E, EPH serves as a positive predictor, demonstrating statistical significance at the 5% level. To enhance the appeal of renewable energy investments, policymakers and financial institutions should eliminate market barriers, mitigate risks, provide technical and financial support for project planning and execution, improve access to funding, and strengthen local lenders' capacity to finance green initiatives.

INTRODUCTION

In recent years, there has been a notable increase in knowledge and understanding of green finance worldwide, alongside a rise in investments in alternative financial products (Lemme, 2024). The Climate Bond Initiative (CBI) reported that global green bonds and loans issued in 2019 totalled $257.7 billion, representing a 51% increase from the previous year (Fauza & Suryomurti, 2024). In June 2019, the Global Sustainable Investment Alliance (GSIA) stated that the total value of assets allocated to sustainable or green investment strategies had reached $30.7 trillion (Gabriel & Pinho, 2024), marking a significant increase of 34 per cent compared to the figure recorded in 2016. To secure a substantial share of the growing sustainable investment assets, Nigeria's government, regulators, financial institutions, and project developers must cultivate effective partnerships (Ugwu et al., 2024). Achieving sustainable development targets necessitates initiating ecologically responsible projects using green financial bonds, banks, carbon market instruments, and other innovative financial tools and regulations (Yekini et al., 2024). This encompasses fiscal policy, an environmentally friendly central bank, financial technology, regionally focused green funds, and improvements in investment funding that provide environmental benefits. These efforts are often called "green finance," which studies suggest will enhance and support initiatives to prevent environmental harm.

The United Nations Sustainable Development Goals (SDGs) and the Paris Climate Agreement, which support the global initiative for climate change mitigation through green finance, highlight a shared commitment to ecological sustainability. Although the United Nations adopted the "2030 Agenda for Sustainable Development" in September 2015, the primary objective among the 17 Sustainable Development Goals is to eradicate global poverty. Worldwide, we continue to face significant developmental challenges arising from poverty. The 2019 Global Multidimensional Poverty Index Report by the United Nations Development Programme indicates that over 1.3 billion people remain in multidimensional poverty, with significant disparities among nations and regions. This situation necessitates innovative financial solutions aligning economic advancement with environmental sustainability, particularly in developing economies like Nigeria.

The International Finance Corporation (IFC) identifies green finance as a crucial catalyst for financial innovation, promoting economic growth and environmental benefits, and it is gaining increasing traction globally. Numerous countries emphasise green financing (Yang & Maron, 2022; Zhang et al., 2023). However, developing economies face unique challenges due to their reliance on resource-intensive growth methods and high carbon footprints. Policymakers and academics are exploring green finance to address these issues, aiming to achieve sustainable development targets by 2030 while fostering economic progress and mitigating environmental damage. Substantial investments in sustainable infrastructure are vital, necessitating a combination of public and private sector funding. This includes the development of innovative financial instruments and strategies to support sustainable infrastructure projects, such as green banks, green bonds, and climate risk insurance.

Although green finance can fulfil sustainable development objectives, the literature reveals divergent perspectives regarding its effects. The predominant research investigates the impact of green funding on the green economy and carbon dioxide emissions. Fukada-Parr et al. (2022) analyse the beneficial effects of investing in environmentally sustainable projects on achieving sustainable development goals. Kara Anderson (2024) finds that investment in private eco-friendly initiatives reduces CO2 emissions and supports the transition of a developing economy towards sustainability and a low-carbon framework. An analysis suggests that promoting green finance and utilising eco-friendly technology are essential for achieving the Paris Agreement and sustainable development goals. This study seeks to explore the impact of green financing on Nigeria's environmental sustainability, focusing on providing a comprehensive understanding of its potential and challenges in realising sustainable development.

Specific Objectives

The study’s specific objectives are as follows;

i. to evaluate the impact of green credit on Nigeria's environmental sustainability.

ii. To assess the impact of green security on Nigeria's environmental sustainability.

iii. to ascertain the impact of carbon finance on environmental sustainability of Nigeria

Research Questions

The study seeks to answer the following questions;

i. Is green credit impacting Nigeria's environmental sustainability?

ii. How does green security impact Nigeria's environmental sustainability?

iii. How has Nigeria’s carbon finance impacted environmental sustainability?

Research Hypotheses

i. H_{01}: There is no significant statistical impact of green credit on the environmental sustainability of Nigeria.

ii. H_{02}: There is no significant statistical impact of green security on the environmental sustainability of Nigeria

iii. H_{03}: There is no significant statistical impact of carbon finance on Nigeria's environmental sustainability

Significance of the Study

This study makes a unique contribution to the existing literature by explicitly analysing the impact of green finance on promoting sustainable development. It helps verify whether green finance meets its goal of reconciling sustainable growth with environmental challenges. Moreover, it integrates green funding, environmental benefits, and economic growth into a cohesive framework and concludes. This will enable policymakers and regulators to develop policies for sustainable development. This paper is deemed valuable as it offers a comprehensive compilation of empirical evidence demonstrating the influence of green finance on sustainable development. This study will enrich the growing body of empirical research and literature. Furthermore, it will enhance the ability to compare its findings with previous research conducted in economies characterised by robust financial and capital markets alongside stable political environments. Additionally, insights on green financing will assist stakeholders in evaluating the current circumstances regarding benefits and drawbacks. This study will establish a benchmark for future research. Likewise, the study's results will refine the methodologies utilised in prior research.

LITERATURE REVIEW

Concept of Green Finance

Green finance involves directing financial resources towards projects, regulations, and products that foster sustainable development and a more environmentally friendly economy. This cutting-edge financial strategy aims to harmonise economic growth with environmental enhancement by funding initiatives that offer ecological advantages (Abdallah & Odeleke, 2023). It goes beyond climate finance to include goals like reducing industrial emissions, improving water quality, and protecting biodiversity (Bergougui, 2024). Key elements include sustainable investing and banking, which entail environmental assessments, risk evaluations to fulfil sustainability criteria, and insurance services designed to address climate-related risks.

Determinants of CO2 Emissions

Many studies have investigated the factors that affect CO2 emissions. Key socioeconomic factors include urbanisation, industrialisation, population growth, and energy consumption. For example, Ma et al. (2019) established a strong connection between CO2 emissions and energy consumption, while Ghazali and Ali (2019) emphasised the population's role as a significant factor. Sarkodie et al. (2019) showed that increasing biomass usage can significantly lower emissions. Additionally, urbanisation and trade activities contribute to environmental decline, as indicated by Saidi and Mbarek (2017); however, financial development can alleviate these effects, mainly when supported by substantial reforms. The varying results regarding the impact of Foreign Direct Investment (FDI) illustrate the effect of geographic and methodological diversity. Some studies report negative consequences (Sarkodie & Strezov, 2019), while others indicate neutral or positive results (Khan et al., 2018).

Environmental Sustainability

Environmental sustainability guarantees that ecosystems remain productive and resilient, supporting human life without exhausting resources. This encompasses the judicious use of natural capital and recognition of its renewability and ecological limits (Gong et al., 2023). Corporate social responsibility (CSR) is vital in sustainability initiatives, emphasising ethical practices and long-term value creation (Masum et al., 2020). Businesses are urged to incorporate sustainability into their strategies to improve societal and financial outcomes. Sustainability strategies encompass environmentally sound practices that ensure competitiveness while addressing ecological and social repercussions (Ahmed & Streimikiene, 2021).

Theoretical Review

The Theory of Environmental Quality and Economic Growth

The Theory of Environmental Quality and Economic Growth suggests that environmental conditions, especially the effective utilisation of natural resources, directly impact economic growth rates. In Nigeria, green financing has the potential to significantly enhance environmental quality by directing investments toward renewable energy, waste management, and sustainable agriculture. These investments can drive economic growth through job creation, poverty reduction, and attracting foreign investors (Nkengafack & Kaffo, 2019). The theory argues that improving environmental quality via green financing can facilitate sustainable development by promoting economic growth and addressing inequality. Green finance is seen as a powerful approach to drawing private investors into sustainable projects, thus aiding sustainability goals (Shujah-ur-Rahman et al., 2019). It improves market transparency and accessibility for eco-friendly activities, encouraging capital mobilisation from private sector investments using specialised instruments. The rapid expansion of the green finance sector in the past decade illustrates its vital role in fostering sustainable economic success (Zhao et al., 2020).

Empirical studies in OECD countries reveal that the size of the green financing market positively influences green growth, highlighting the significance of private sector investments in fostering environmentally beneficial initiatives. Improving natural resource efficiency and decreasing reliance on fossil fuels are key drivers for green projects. However, the social inclusion index seems to have little effect, likely due to the prevalence of industrial economies in OECD countries (Han & Gao, 2024; Paramati, 2022). The literature review underscores the profound impact of green financing on enhancing sustainability at the national level, emphasising the necessity for clear regulations, financial system transparency, and increased public awareness as essential components for successful green financing initiatives (Sohail et al., 2021). The findings suggest that green finance propels sustainability outcomes by facilitating the growth of green capital and boosting private sector involvement in green initiatives.

Theoretical Framework

Introduction to Climate Finance and Greenhouse Gas Disclosure

Conflicting evidence surrounds the impact of greenhouse gas disclosure on financial performance. Some research indicates a negative correlation between financial performance and carbon emissions disclosure (Abubakar et al., 2021), while other studies reveal either negligible or positive associations (Khan et al., 2022; Ma et al., 2022). Although Nigeria is Africa's third largest recipient of climate funding, the $1.9 billion received is insufficient considering its economic scale and low-carbon growth prospects. To fulfil the nation’s Nationally Determined Contributions (NDC), an annual investment gap of $15.8 billion is necessary.

Companies prioritise economic achievements over environmental consequences (Irwhantoko & Basuki, 2016), but embracing sustainable practices provides competitive benefits and attracts investors (Okpala & Iredale, 2019). Investors are increasingly inclined to support firms that tackle environmental issues, especially carbon emissions (Berthelot et al., 2012). Nevertheless, the financial market may view carbon disclosures negatively, perceiving them as expensive and potentially unproductive (Ling & Mowen, 2013). This study tests three hypotheses:

1. H01: Green credit has no significant statistical impact on environmental sustainability in Nigeria.
2. H02: Green security has no significant statistical impact on environmental sustainability in Nigeria.
3. H03: Carbon finance has no significant statistical impact on Nigeria’s environmental sustainability.

Institutional Framework and Financing Trends

Nigeria has developed a robust framework for green bonds involving the Federal Ministry of Environment alongside various governmental agencies. The issuance of $165.1 million in sovereign green bonds has created a platform to draw local and international investors (DCC, 2020). Income generated from sovereign and sub-sovereign green bonds is tax-exempt, with funded projects required to showcase measurable environmental benefits in line with international standards.

Climate financing in Nigeria is primarily sourced from public funding (77%), while the private sector contributes a mere 23%. Public funding is directed through Multilateral Development Finance Institutions (55%), Bilateral DFIs (20%), and government bodies (19%). Contributions from the private sector come from corporations (34%) and financial institutions (12%), yet these amounts fall short of meeting Nigeria's NDC targets and objectives for low-carbon development. Although Nigeria successfully attracts private investment at a higher rate than the African average (23% versus 14%), fossil fuel investments significantly overshadow the total climate finance. For instance, a single LNG project secured $2.77 billion, surpassing the total climate finance registered for 2019/2020 (Geuskens & Butijn, 2022).

There are considerable investment gaps in key sectors essential for reaching climate targets. The $798 million dedicated to clean energy investment pales compared to fossil fuel financing, indicating a misalignment with low-carbon development goals. Nigeria's role as a significant LNG exporter and response to European energy shortages further complicates its shift towards a sustainable energy future.

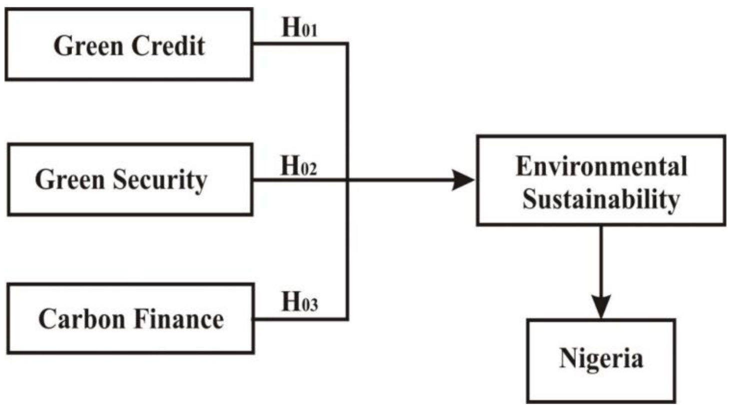

Figure 1: Study's Conceptual Framework

Source: Author's Construct, (2023)

Empirical Review of Related Studies

Afaq et al. (2024) highlighted the urgent need for green finance ecosystems to combat climate change and promote environmental sustainability. Green finance refers to investments in sustainable projects, including eco-friendly technologies and infrastructures. Their research evaluated the development and effectiveness of green financing systems in the United Kingdom and Pakistan, demonstrating strong positive links between green funding and environmental sustainability dimensions in both countries, with the UK outperforming Pakistan. Underutilised equity instruments, political risks, and insufficient ecological disclosure practices challenge Pakistan. As a result, they recommended enhancing legislative incentives, addressing implementation barriers, and developing diverse green investment strategies.

Hishamuddin et al. (2024) used panel data from 2010 to 2019 to explore the mediating role of green funding in the connection between climate change and bank stability in ASEAN countries. Their analysis of CO2 emissions, bank size, credit risk, and liquidity risk indicated that green financing positively affects bank stability. The report encouraged embracing green funding policies, strengthening financial stability through green initiatives, and creating regulatory frameworks to mitigate the impacts of climate change.

Afeef et al. (2024) assessed the impact of green financing initiatives on the sustainable development goals in Jordan, focusing on environmental sustainability, economic growth, and social progress. The study aimed to evaluate the effects of increased ecological project loans from banks on sustainability in Jordan. Employing the Autoregressive Distributed Lag (ARDL) approach, it examined the relationship between green financing and sustainable growth while including control variables such as income, population, trade openness, and urbanisation. The findings confirmed that green financing positively impacts sustainable development, fostering a virtuous cycle between green finance and sustainability. The study also recommended enhanced governmental incentives for green investments and further research on green finance's role in sustainable development.

Abdallah and Odeleke (2023) investigated Nigeria's energy security challenges and forecasts, aiming to identify Nigeria's energy security concerns and opportunities. This theoretical study reviewed multiple sources and is critical for policymakers to develop effective and efficient energy security policies for Nigeria. The government is urged to take deliberate actions to encourage energy independence by setting new fuel economy standards. Prioritising renewable energy sources like solar, wind, and biomass is also essential. Additionally, diversifying the economy should be a key goal, fostering public and private investment in the energy sector to improve its effectiveness and efficiency, ultimately leading to lower oil prices.

Feng and Yang (2023) argue that green financing, which prioritises environmental sustainability and long-term economic development, influences both the demand and supply for eco-friendly growth. This progression guides companies towards sustainable manufacturing and encourages green consumer behaviour. Their research examined the effects of green financing and government spending on sustainable development and CO2 emissions within the Belt and Road Initiative (BRI) countries, assessing how human capital impacts carbon emissions. Data analysis from 57 BRI economies (2005-2020) revealed that green financing, government expenditure, and the square of GDP per capita contribute to reducing CO2 emissions, while human capital similarly has a positive effect. The report advocates for developing advanced human capital to boost economic growth and mitigate climate change, suggesting that this approach may be more effective than regulatory measures. Future studies should explore the impact of government spending on carbon emissions in emerging economies.

Wu (2023) noted that with the decline of the world's ecological environment, sustainability increasingly becomes central to economic development. Promoting green finance can help balance environmental concerns with economic growth, thus fostering sustainable development. Since the Industrial Revolution, the relationship between humanity and nature has shifted from a relatively stable state to a significant imbalance. This shift poses major threats to economic development and emphasises the need to integrate sustainability into economic progress.

Anas et al. (2023) examined the impact of green finance and technological innovation on environmental sustainability in six emerging economies from 2000 to 2018. Their research utilised the cross-section augmented autoregressive distributed lags (CS-ARDL) model, validated by common correlated mean group (CCEMG) and augmented mean group (AMG) techniques, showing that both green finance and technology have a positive effect on sustainability, while resource depletion negatively impacts it. The study recommends focusing on Reducing Emissions from Deforestation and Forest Degradation (REDD+) projects, implementing resource decoupling regulations, and enhancing the integration of green finance and technological innovation. It underscores the importance of green finance for economic and environmental advancement in emerging economies.

METHODOLOGY

Study Population

Population refers to the complete set of individuals, elements, or units that share common characteristics and are the main subject of investigation, representing the broader group that may be studied. The study's demographic includes historical trends from 2009 to 2023, concentrating on Nigeria's green finance, which encompasses green lending, green securities, carbon financing, and environmental sustainability.

Sources and Methods of Data Collection

The data used in this study is secondary. The information was gathered from reputable agencies, including the National Bureau of Statistics, the annual report on green finance, and the CBN statistical bulletin, covering the period from 2009 to 2023. These will be sourced from various editions of the CBN Statistical Bulletin beginning in 2020 when the monetary authority was established. The data consists of an annual time series from 2017 to 2024 (World Bank Annual Report, 2023), utilising secondary data collection methods.

Instruments of Data Collection

The researcher employed annual time series data from various sources, including the World Bank Annual Report, the National Bureau of Statistics, annual reports on exchange rates, and the Central Bank of Nigeria (CBN) statistical bulletin regarding Nigerian green finance. The data spans 2009 to 2024 and focuses on green credit, green investment, green securities, carbon finance, and sustainable development.

Method of Data Analysis and Model Specification

This study will utilise descriptive statistics to summarise the dataset. This encompasses various statistical measures, such as the mean, median, and mode for central tendency and the standard deviation, variance, minimum, maximum, kurtosis, and skewness for variability within descriptive statistics. For inferential statistics, unit root tests, co-integration tests, panel cointegration, and estimation of panel cointegration regression will be applied. In contrast, the dynamic fixed effect model determines the impact. This study utilises the model proposed by Kwilinski et al. (2023) as well as the analysis by Ewubare et al. (2019), where sustainable development, represented by environmental sustainability and economic sustainability, was examined about green credit, green security, and carbon financing. The specific functional relationship between environmental sustainability and green finance is defined as follows:

ENVSUS = ƒ (GREFIN)………………………………………………………………. (3.2)

Therefore, the econometrical form of the equation becomes:

The model is formulated to capture the relationship between the effect of green finance and sustainable development during the period under review. The model is explicitly expressed as:

$Model: ENVSUS = \alpha + \beta_1 GRECRE_t + \beta_2 GRESEC_t + \beta_3 CARFIN_t + \mu_t$. (3.2)

Where;

ENVSUS = Environmental Sustainability

GRECRE = Green Credit

GRESEC = Green Securities

CARFIN = Carbon Finance

α = Constant term

μ = error term

t= time

β_1- β_3 = Coefficient of the variables

The Model Transformation using the proxies for this study shows that;

$Model: CO_2E_t = \alpha + \beta_1 GRL_t + \beta_2 EPH_t + \beta_3 CO_2F_t + \mu_t$. (3.3)

Where;

$CO_2E = ENVSUS = CO_2\ emissions\ (kt)$

$GRL = GRECRE = IBRD\ loans\ and\ IDA\ credits\ (DOD, current\ US\$)$

$EPH = GRESEC = Electricity\ production\ from\ hydroelectric\ sources\ (\%\ of\ total)$

$CO_2F = CARFIN = Adjusted\ net\ savings, including\ particulate\ emission\ damage\ (current\ US\$)$

ANALYSIS AND RESULTS

Overview of the Data

The descriptive statistics for the variables considered in this study are indicated in Table 1, which includes CO2E, GRL, EPH, and CO_2F. The mean for the variables entails 106482, 8.2E+09, 19.1516 and 2.9E+10, while the ranges show 42596.70, 2.8E+10, 6.81 and 7.8E+10 for CO_2E, GRL, EPH and CO_2F respectively. This means that the CO_2E has the highest mean and range values. The minimums and maximum entail .00 and 7.8E+10 for GRL and CO2F, respectively. The variables with the most significant sum and standard deviation include 4.32E+11 and 2.4E+10, both for CO_2E. At the same time, the highest variance, skewness and kurtosis encompass 5.723E+20, 2.066 and 5.845, respectively, for CO2E, GRL and GRL in line with the outcome of this study.

Table 1: Study's Descriptive Statistics

Statistics	CO_2E	GIRL	EPH	CO_2F
Mean	106482	8.2E+09	19.1516	2.9E+10
Range	42596.70	2.8E+10	6.81	7.8E+10
Minimum	76947.4	.00	17.59	38735.93
Maximum	119544	2.8E+10	24.40	7.8E+10
Sum	1597228	1.3E+11	287.27	4.32E+11
SD	3056.08	1.6E+09	.54602	2.4E+10
Variance	1.4E+08	4.2E+19	4.472	5.723E+20
Skewness	-1.383	2.066	1.735	.985
Kurtosis	1.382	5.845	1.854	.098

Test of Multicollinearity using Variance Inflation Factor (VIF)

Table 2 presents the variance inflation factor (VIF) result used to check for multicollinearity among the variables of interest. It shows a robust correlation between two or more regressors, making it almost impossible to distinguish the effect of each of the concerned regressors on the response variable (Muhammed & Adindu, 2023). It simply captures the movement of two or more regressors moving simultaneously in the same direction and rate. Accordingly, seeing that all the regressors show a VIF value of less than 6 each, which is well below the benchmark of less than 10 (Agubata et al., 2022), which means that a robust outcome is expected by applying the panel least square estimators without necessarily logging the variables.

Table 2: Test of Multicollinearity

Model Coefficients		Collinearity Statistics	
		Tolerance (1/VIF)	VIF
	CO2E	.297	5.34
	GIRL	.820	1.06
	EPH	.571	4.05
	CO2F	.216	1.17
a. dependent variable: T1CR			

Unit Root test

Table 3 shows the raw and differenced data results after undergoing the Augmented Dickey-Fuller and Phillips Perron tests. As previously stated, analysis based on time series requires the data to be stationary, as non-stationary data leads to misleading inference. So, the unit root test is employed to test for the data's stationary nature through the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests. The series is expected not to contain unit roots to find relationships among the variables in the long run. The test is carried out at the level and first difference using a 5% Mackinnon Critical value (Iwegbu et al., 2019). The ADF and PP test results show that all the variables are not stationary at levels, as the absolute value of their respective t-statistics values is less than the absolute 0.5% critical value in both tests. However, after testing them at their first difference, they were all stationary as all the variables are integrated in the same order of 2. The result is consistent with findings from Muhammed (2023), whose variables became stationary at first difference. Therefore, the co-integration test is necessary to further check the long-term relationship among the variables (Iwegbu et al., 2019).

Table 3: Results of Augmented Dickey-Fuller Test & Phillips Perron at the level and first difference

Variables	T-Statistics	Lag Order	P-Value	Alterlocal Hypothesis	Remark
ADF at First Difference					
CO_2E	-2.2849	2	0.4617	Stationary	Not Stationary
GIRL	-2.2850	2	0.4616	Stationary	Not Stationary
EPH	-2.0291	2	0.4914	Stationary	Not Stationary
CO_2F	-2.2849	2	0.4616	Stationary	Not Stationary
Phillips Perron Test at Level					
CO_2E	-30.12	3	0.3134	Stationary	Not Stationary
GIRL	-30.042	3	0.3312	Stationary	Not Stationary
EPH	-46.019	3	0.3727	Stationary	Not Stationary
CO_2F	-30.980	3	0.3881	Stationary	Not Stationary
ADF at First Difference					
Variables	T-Statistics	Lag Order	P-Value	Alterlocal Hypothesis	Remark
CO_2E	-3.5865	2	0.04703	Stationary	Stationary
GIRL	-3.5857	2	0.04709	Stationary	Stationary
EPH	-4.0502	2	0.01812	Stationary	Stationary
CO_2F	-3.5854	2	0.04711	Stationary	Stationary
Phillips Perron Test at First Difference					
CO2E	-31.440	3	0.01	Stationary	Stationary
GIRL	-31.437	3	0.01	Stationary	Stationary
EPH	-47.628	3	0.01	Stationary	Stationary
CO_2F	-31.434	3	0.01	Stationary	Stationary

Co-integration Test

Table 4 shows the Eigen normalised cointegration relations and Eigen weights loading matrix in the Johansen Cointegration analysis. The Johansen test for Cointegration was employed to test the long-run relationship among the variables. When two or more time series data are cointegrated, it means a long-run statistical relationship (Selva, 2019). The procedure for the cointegration test began with the null hypothesis that there is no cointegration among the systems of equations in the VAR model. A rejection of this hypothesis implies the existence of Cointegration among some or all the equations. Consequently, the second part of the divide indicates the existence of a run relationship among all 5 equations in the model, which shows the rejection of the null hypothesis at a 5% level of significance, depicting that the series is cointegrated because the individual time series has an integration order that is more than the linear combination of the time series. The Linear combination of the six-time series variables is s = 1.00000000* BM2GDP + 0.20841780*DIR - 2.26269956*BZ - 0.00170223*DCPGDP - 0.20648718*BBA + 0.09842796. The linear combination shown above indicated the ADF value of -3.786, a Lag order of 3 and a p-value of 0.03121, posting that there is enough evidence to reject the null hypothesis since the p-value is less than the 0.05 significance level. This shows a relationship between the variables considered for this study for the period under review.

Table 4: Johansen Test for Co-integration

Values of Test Statistics and Critical Test					
	Test	10pct	5pct	1pct	
r <=4	0.15	6.50	8.18	11.65	
r <=3	9.86	15.66	17.95	23.52	
r <=2	27.30	28.71	31.52	37.22	

r <=1	46.73	45.23	48.28	55.43	
r =0	72.00	66.49	70.60	78.87	
Eigen Normalized Cointegration Relations					
CO2E	1.000000000	1.000000000	1.000000000	1.000000e+00	1.000000e+00
GIRL	-2.26269956	0.0984279616	7.190007492	2.635706e+02	1.212376e+02
EPH	-0.00170223	-0.0009931287	0.001297502	4.070976e-04	-3.25904e-04
CO2F	-0.20648718	0.0751322215	-0.686281351	-1.864070e+01	-8.9172e+00
Eigen Weights Loading Matrix					
CO2E	-39.07648	31.14213	-10.341738	1.2054421	-1.3947355
GIRL	-19.32974	15.70237	-4.902729	0.5921169	-0.6963618
EPH	98.82181	328.05318	-449.670120	-1.8916763	-5.4921012
CO2F	-274.97971	223.39939	-69.758759	8.4613450	-9.9094210

Eigenvalues (lambda): 0.485741886, 0.400250946, 0.368052165, 0.225553304, 0.003827619 and 0.09842796 for the six variables considered in this study.

Diagnostic Test

To ensure the efficiency of the VAR model and its correlation with the white noise assumption, a residual-based test of Breusch-Godfrey L-M test for autocorrelation, Jarqui Berra test for normality, Lagrange multiplier (LM) test, and Hausman test were conducted for the employed model.

Residual Autocorrelation Test

The LM Serial Correlation Test was employed for the system model to test for residual autocorrelation among the variables, as indicated in Table 5.

Table 5: Residual Serial Correlation LM Tests

Covariance Matrix of the Residual						
CO_2E	387.13	1.389681	192.8928	1268.800	2744.508	138.9681
GIRL	192.89	0.692393	96.1135	632.210	1367.517	129.852
EPH	1268.80	4.554501	632.2101	4158.519	8995.182	138.211
CO_2F	2744.51	9.851868	1367.5170	8995.182	19457.244	1268.80
Correlation Matrix of Residuals						
CO_2E	1.0000	.9904	1.0000	1.0000	1.0000	.9904
GIRL	1.0000	.9903	1.0000	1.0000	1.0000	.9903
EPH	1.0000	.9903	1.0000	1.0000	1.0000	.9903
CO_2F	1.0000	.9903	1.0000	1.0000	1.0000	1.0000

The LM Serial Correlation Test was employed to test for residual autocorrelation among the variables. The result shows the rejection of the null hypothesis that no autocorrelation exists among the residuals, and the probability of the observed LM statistics must be greater than 5%. The result depicts a rejection of the null hypothesis for all the lags, implying the inexistence of serial correlation among all the variables in the VAR model.

Normality Test

The multivariate normality test result for the VAR model is depicted in Table 6 below. It indicates the rejection of the null hypothesis, which is the residuals or error terms in the VAR System. This shows that they are generally distributed with the combined p-values of Jarque-Bera, skewness, and Kurtosis probability statistics, which is less than the 5% significance level. The result posited that all 5 equations in the model are normally distributed.

Table 6: Multivariate Normality Test

Jarque-Bera Test		
Chi-Squared	Df	p-value
353.69	10	<2.2e-16
Skewness		

63.126	5	2.742e-12
Kurtosis		
290.56	5	<2.2e-16

Serial Test

Table 7 outlines the Portmanteau test output for the equation. It indicates that the probability of the p-value of 0.000212, which is less than the 0.05 significance level, implies the rejection of the null hypothesis that the residual value is serialised; therefore, we can conclude that the residual value of the dependent variable is not correlated with the error term.

Table 7: The Portmanteau test (asymptotic)

Chi-Squared	df	p-value	Significance Level
234.04	175	0.000212	0.05

Lagrange Multiplier Test (LM)

The LM test for the considered variables is illustrated in Table 8 for CO_2E and using CO2E as the measure of environmental sustainability) at the 5% significance level; the LM test is statistically significant, suggesting the presence of random effect in the cross-section and invariably nullifying the viability of using the standard effect estimates for testing the proposed hypothesis in this study. Alternatively, the Hausman test is required to determine between the fixed and random effects, which is the most appropriate for testing the proposed hypothesis.

Table 8: Lagrange Multiplier Test (LM) for CO_2E

Breusch and Pagan Lagrangian multiplier test for random effects

CO_2E[CROSSID,t] = Xb + u[CROSSID] + e[CROSSID,t]

	Vars	Sqrt (Var)
CO_2E	4.998315	2.235691
e	2.538115	1.593146
you	1.740929	1.319443

Test: Var(u) = 0; chibar2(01) = 52.96; Prob> chibar2 = .0000

Hausman Test

The Hausman test for the variables considered in this study has a CO_2E model illustrated in Table 9. The model using the CO_2E has a p-value of 0.8190, which is statistically insignificant at all levels of significance, thereby implying that the random effect estimate is more appropriate for the data in the current compared to the fixed effect and common effect estimators. Thus, the study uses the random effect estimate to test the proposed hypothesis.

Table 9: Hausman Test for the CO_2E Model

	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	Fixed	Random	Difference	SE
CO2E	-.0530545	-.047874	-.00518	-2.68376E-05
GIRL	.0129517	.011020	.009132	-3.73146E-06
EPH	.0111067	.022810	-.0117	-0.000136967
CO2F	.7368197	.3072263	.429593	-0.184550489

b = consistent under Ho and Ha; obtained from xtreg B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic chi2 (5) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 2.94 Prob>chi2 = 0.6191

Panel Regression Model

Table 10 presents the regressed results from the common, fixed, and random effect estimators, with CO2E (dependent variable) representing Nigeria's environmental sustainability measure. The model estimate in italics is the selected estimate for hypothesis testing, as validated by the ML and Hausman tests. Thus, the random effect estimate (REM) is presented for discussion in the current study for the CO_2E model.

Table 4.10: Estimated Results

CO_2E	Pooled Effect Model (PEM)			Fixed Effect Model (FEM)			Random Effect Model (REM)		
	Coef.	T	P>|t|	Coef.	T	P>|t|	Coef.	Z	P>|z|
CO_2F	.0502442	-2.19	0.031	.012415	-.091	-2.485	-.0367631	-1.80	0.072
GIRL	.0045643	1.10	0.274	.0034654	-.398	-4.68E-11	-.002511	-0.17	0.063
EPH	.0085795	3.54	0.001	.0059758	.952	.698	.0265807	2.75	0.006
_cons	-4.68E-11	-1.21	0.227	-2.64E-8	-0.06	0.950	-.0857249	-0.07	0.941
Number of groups	5			5			5		
Number of obs	70			70			70		
F (5, 69)	8.90			4.00			6.24		
Prob > F	.000			.000			.000		
R-squared	.9642			.9030			.9110		
Adj R-squared	.7345			.6740			.6011		

From the table, the CO_2E REM have coefficients of -.0367631, -.002511 and .0265807 for CO_2F, GRL and EPH respectively. This means that while CO_2F and GRL are negative predictors of CO_2E with a negative impact, EPG is its positive predictor with a positive impact and consequently shows that with a Sig (<0.05) signifying the rejection of all the hypotheses, including the H_{01}, H_{02}, and H_{03}. The regression line for the CO_2E model indicates **CO_2E = -.0857249 - .0367631(CO_2F) - .002511 (GRL) + .0265807(EPH),** in line with the outcome of this study, meaning that their impact is significant and minimal as delineated by its coefficient value. Its R-Square value of .9110 reinforces this, representing a 91 per cent impact on CO_2E.

DISCUSSIONS

This study indicates that green credit, security, and carbon finance significantly influence Nigeria's environmental sustainability. This intensifies the global reliance on fossil fuels, significantly affecting the environment. Fossil fuel emissions of carbon dioxide significantly contribute to global warming (May & Crok, 2024). Energy consumption will inherently elevate emission levels (Wang & Azam, 2024). Global warming is attributable to rising greenhouse gas concentrations (GHGs) from human activity. In 2014, a 90% rise in greenhouse gas concentrations was attributed to carbon dioxide emissions, with 68% originating from the energy sector, primarily due to fuel carbon oxidation (Ghorbal et al., 2024). Environmental sustainability necessitates a transition from conventional to more eco-friendly energy sources, as this could improve environmental circumstances without compromising economic development. The energy shift might foster economic growth by providing affordable, accessible, and efficient energy for individuals of all income levels while enhancing environmental conditions by reducing carbon dioxide emissions (Yuan et al., 2022). This analysis concurs with Olaniyi et al. (2024) on the United Nations Environment Program's emission gap report, which emphasises that the most pressing issue for achieving carbon neutrality is the decarbonisation of the electrical sector. This is due to the significant social and environmental consequences of fossil fuel overconsumption, as demonstrated by the study's findings. The IBRD loans and IDA credits, hydroelectric electricity production, and adjusted net savings—including particulate emission damage—serve as proxies for green credit, green security, and carbon finance, respectively. These factors collectively affect the country's environmental sustainability, as evidenced by their combined R-Square value of 0.9110, indicating an approximately 91 per cent impact.

This finding corroborates earlier research by Adebayo et al. (2024) and Meng et al. (2024), which demonstrated that green credits, carbon finance, and carbon securities contribute to the reduction of CO_2 emissions and promote environmental sustainability. In Nigeria, a significant correlation exists between CO2 emissions and environmental sustainability, wherein increased carbon finance and securities result in decreased CO_2 emissions. This results from the country's reliance on assimilating existing advancements from other nations rather than fostering its own, leading to a preference for foreign technology over the development of domestic innovations, potentially resulting in adopting environmentally harmful technologies. Thus, any reduction in carbon financing significantly exacerbates CO_2 emissions in Nigeria. For instance, diminished carbon funding may manifest in several ways, including reducing governmental expenditure on research and development. This may result in a deficiency of new technologies and a rise in CO_2 emissions, as similarly reported by Han et al. (2024) in China and Petrović and Lobanov (2020) in OECD countries. Furthermore, the utilisation of unsuitable technology for oil and gas extraction may increase CO_2 emissions, particularly in the Niger Delta region, due to insufficient funding in certain instances and corruption in others. In contrast, related research by Sadiq et al. (2024) and Zhang and He (2024) concluded that carbon finance could escalate CO_2 emissions at elevated levels. The origin of these discrepancies in the results is indeterminate. Nonetheless, the difference may stem from the differing methodologies employed in the various studies. This research solely investigates the unilateral impact of carbon money on CO_2 emissions, unlike prior studies that have explored the bilateral influence.

Moreover, Nigeria's significant reliance on fossil fuels and its underdeveloped renewable energy sector render this situation unsurprising (Obada et al., 2024). Notwithstanding Nigeria's significant natural gas reserves, initiatives to reduce the consumption of oil, coal, and natural gas will necessitate importing inferior-quality oil from foreign countries like Malta, leading to increased environmental degradation (Odizuru-Abangwu, 2024). Consequently, Nigeria ought to explore strategies to reduce its reliance on fossil fuel energy (FFE) and augment the utilisation of renewable energy sources. This would improve its ecological efficiency and reduce CO_2 emissions. Nevertheless, an augmentation in renewable energy does not exert a substantial influence. Kartal's (2024) and Yuan et al. (2022) studies also showed similar results. These studies demonstrate that renewable energy sources exhibit minimal to negligible CO_2 emissions, as they originate from non-fossil resources, in contrast to traditional energy sources, which contribute to CO_2 emissions reduction. Soubra and Ng (2017) have shown that using renewable energy (RE) reduces CO_2 emissions in Nigeria. They acknowledged renewable energy as essential in mitigating CO_2 emissions and fostering sustainable growth. B´elaïd and Youssef (2017) and Sari Hassoun et al. (2019) have similarly emphasised that an increase in RE significantly addresses technical challenges, like electricity supply shortages and inadequate infrastructure, in countries like Algeria. According to the International Renewable Energy Agency, renewable energy technologies offer the most effective and cost-efficient approach to attain a 90% reduction in carbon dioxide emissions associated with energy use (Adebayo et al., 2023).

CONCLUSION AND RECOMMENDATIONS

This study that explored the impact of green financing on the environmental sustainability of Nigeria with a focus on providing a comprehensive understanding of its potential and challenges in achieving sustainable development concludes that the CO_2E REM have coefficients of -.0367631, -.002511 and .0265807 for CO_2F, GRL and EPH respectively. This means that while CO_2F and GRL are negative predictors of CO_2E with a negative impact, EPG is its positive predictor with a positive impact and consequently shows that with a Sig (<0.05) signifying the rejection of all the hypotheses, including the H_{01}, H_{02}, and H_{03}. The regression line for the CO_2E model indicates **CO_2E = -.0857249 - .0367631(CO_2F) - .002511 (GRL) + .0265807(EPH),** in line with the outcome of this study, meaning that their impact is significant and minimal as delineated by its coefficient value as reinforced by its R-Square value of .9110 representing about 91 per cent impact on the CO_2E. The following recommendations are inferred from this study's conclusion;

Based on the study's results, the following five recommendations are proposed:

1. Policymakers and public financial institutions should eliminate market barriers and mitigate investment risks to enhance the attractiveness of renewable energy projects. This can be achieved by providing financial incentives, tax reliefs, and technical support to encourage investments in solar, wind, and hydro energy sources.
2. The Central Bank of Nigeria (CBN) and financial regulators should implement policies that promote green lending and carbon finance. This includes offering low-interest loans to businesses investing in eco-friendly projects and enforcing stringent environmental sustainability requirements for credit issuance.
3. Deposit Money Banks (DMBs) should integrate sustainability metrics into their lending criteria, ensuring that loans are directed toward environmentally sustainable projects. Regulators should mandate financial institutions to disclose their environmental impact and compliance with green financing guidelines.
4. The Nigerian government should collaborate with private investors to fund large-scale green infrastructure projects. Public-private partnerships can facilitate the development of green bonds, eco-friendly industrial zones, and sustainable agricultural initiatives that contribute to long-term environmental sustainability.
5. Government agencies, financial institutions, and non-governmental organisations should intensify public awareness campaigns on the benefits of green financing. Capacity-building programs should be introduced to train financial professionals, policymakers, and business leaders on innovative green finance instruments and sustainability strategies.

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