Green Finance and Environmental Sustainability in the West African Monetary Zone (WAMZ)

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ABSTRACT

This study provides empirical evidence on how different forms of green finance affect environmental sustainability in the West African Monetary Zone (WAMZ), comprising Nigeria, Ghana, The Gambia, Sierra Leone, Liberia, and Guinea. The specific objectives are to determine the effects of international finance for clean energy, total donations for biodiversity conservation, international financial support for green infrastructure, and technical cooperation grants on carbon dioxide (CO_2) emissions. This study relied on panel datasets gathered from the Global Carbon Budget, the Organisation for Economic Co-operation and Development (OECD), and the United Nations, and analysed using descriptive statistics, a panel unit root test, and a random-effects static regression. The findings showed that international funding for clean energy has a negative impact on annual CO_2 emissions. Although this result is not significant at the 5% level, it suggests that funds from donor agencies for clean energy could reduce CO_2 emissions across WAMZ member countries. Similarly, the results showed that total donations directed towards biodiversity conservation significantly reduced annual CO_2 emissions in the WAMZ during the study period. This suggests that donor-funded projects, such as reforestation, habitat restoration, protected area management, and anti-deforestation efforts, are delivering meaningful environmental benefits in the WAMZ. Additionally, the results showed that international financial support for infrastructure and technical cooperation grants positively and significantly affected annual CO_2 emissions. This finding indicates that these funding sources have not translated into environmental sustainability, which may be linked to poor institutional quality, managerial inefficiency, and a limited focus on low-carbon technologies in the funds' investments. Given the findings, it is recommended, among others, that policymakers in the WAMZ should strengthen project appraisal frameworks and prioritise high-impact renewable energy initiatives to ensure clean energy financing is effectively utilised and results in significant CO_2 emission reductions. It is also recommended that governments in the WAMZ enhance their institutional frameworks for conservation management to secure increased funding through international grants and climate funds dedicated to environmental sustainability in the region.

INTRODUCTION

Green finance involves channelling capital into environmentally sustainable projects, including transitioning to clean, modern energy sources, improving energy efficiency, safeguarding natural ecosystems, and developing low-carbon infrastructure. It is widely recognised as a way to achieve the dual goals of economic growth and environmental protection. Zhang & Xi (2024) posit that green finance offers favourable terms for projects that deliver environmental benefits, such as renewable energy installations or energy efficiency upgrades, thereby making them more appealing to private investors. Similarly, Monasterolo (2020), Zhou, Wu & Zhou (2023), and Fu, Lu & Pirabi (2023) highlight the fundamental role of green finance in mitigating climate change by reducing climate-related risks, thereby creating more opportunities for environmental sustainability.

Furthermore, Çıtak & Hoş (2024) describe the goal of green finance as addressing climate change, promoting the sustainable use of natural resources, and backing eco-friendly economic initiatives. They also clarify that it involves developing and promoting financial products and services that emphasise environmental responsibility. Green bonds specifically raise funds for climate-friendly projects, providing a safe and

profitable way for companies to support environmental sustainability (Kumar & Sharma, 2023 and Mudalige, 2023). Similarly, Khan et al. (2024) posit that by reducing financial barriers and risks associated with green projects, green finance tools enhance private-sector contributions to the development and expansion of sustainable infrastructure.

In addition, green finance has been recognised for integrating Environmental, Social, and Governance (ESG) criteria into financial decision-making, providing a pathway for prioritising environmental considerations. Green finance is a critical enabler of environmental sustainability as it channels direct investments toward eco-friendly projects and encourages sustainable practices (Çıtak & Hoş, 2024). Pasupuleti & Ayyagari (2023) highlight that green finance enhances environmental sustainability by incentivising businesses to adopt greener practices through various regulatory and market-based tools. Green finance also ensures the availability of capital for renewable energy, energy efficiency, clean technology, and pollution control projects, which are germane for environmental sustainability (Omri, Jarraya & Kahia, 2025).

In Africa and Nigeria in particular, green finance has emerged as a critical policy and investment instrument for achieving long-term sustainability in accordance with the Sustainable Development Goals (SDGs). Lwesya (2025) posits that green finance across the African continent is targeted at bridging the financing gap for sustainable development and climate resilience. This follows the growing threats posed by climate change, biodiversity loss, and environmental degradation. However, there has been growing concern about meeting the green financing need as Lwesya (2025) highlights that Africa requires an estimated $1.3 to $1.6 trillion in climate finance between 2020 and 2030 to meet its sustainable development goals. Given the controversies surrounding green finance in Africa, it is imperative to examine its scale and its contribution to environmental sustainability in the West African Monetary Zone (WAMZ), comprising Nigeria, Ghana, The Gambia, Sierra Leone, Liberia, and Guinea.

LITERATURE REVIEW

THEORETICAL LITERATURE

This study is anchored on the double dividend hypothesis proposed by Pearce (1991), which posits that environmental taxes and green investments offer two main benefits: decreasing environmental harm and enhancing economic efficiency. The primary dividend focuses on pollution reduction by making it more costly to pollute, prompting businesses and consumers to adopt cleaner options. The secondary dividend involves using the revenue from these taxes to lower other distortionary taxes, thereby boosting economic efficiency, investment, employment, and overall welfare. Oates (1995) further expanded this idea, proposing that environmental taxes can both protect the environment and generate revenue to cut taxes on employment, investment, and consumption. In this context, green finance is seen as a channel for reallocating resources from harmful activities to sustainable ones, helping combat climate change and environmental damage.

This theoretical view emphasises the role of green instruments, such as green investments, green loans, and green bonds, in reducing the carbon intensity of economic activities, particularly in emerging economies. In essence, the theory implies that environmental taxation can be "win–win" by addressing both green and economic concerns simultaneously. The Double Dividend Hypothesis provides a theoretical explanation of blending environmental taxation and green fiscal policies. Carbon or pollution taxation, and the use of the revenue to finance green investments, renewable energy, and sustainability financial incentives, allow member countries to pursue both economic growth and environmental protection. This aligns with sustainable finance principles that facilitate optimal resource use for low-carbon development and resilience building in emerging economies. Double Dividend Theory aligns with the green finance objective by stipulating how green incentives and ecotaxes can raise funds to finance green investment without harming economic performance. In the proposition of double dividend theory, green financial instruments such as green bonds, carbon credits, and sustainability linked loans are market-driven instruments that internalise the environmental cost while spurring innovation and investment. However, critics argue that while the theory of the double dividend in itself provides a robust conceptual framework for uniting fiscal policy and sustainable goals, its assumptions and practice in numerous instances fall short of the complexity of today's systems of green finance, particularly in emerging economies.

Empirical Literature

Li & Song (2025) employed the Difference-in-Differences (DID) method and the Spatial Durbin Model (SDM) to examine the effect of China's Green Finance Reform and Innovation Pilot Zones (GFRIPZs) on urban Green Development Efficiency (GDE). The findings showed that GFRIPZs significantly enhance urban GDE. The policy's effects exhibit significant heterogeneity, with stronger effects in the eastern and central regions than in the western region, while non-resource-based cities benefit more than resource-based counterparts. Spatially, GFRIPZs generate positive direct effects within pilot cities alongside negative spill-over effects on neighbouring urban areas. The study further revealed that the mechanisms driving the GDE improvement include expanded corporate financing scale, reduced corporate financing costs, promotion of industrial restructuring, stimulation of technological innovation, and enhanced efficiency in resource allocation. The results underscore the need for tailored regional strategies, targeted support for resource-based cities, and optimised spatial coordination to maximise the efficacy of green finance initiatives.

Utilising the panel quantile autoregressive distributed lag (P-QARDL) model and Granger non-causality in heterogeneous panels, Marashdeh & Khataybeh (2025) examined the role of green finance and financial development in delivering environmental sustainability in Gulf countries between 2001 and 2022. The results indicate that green finance is not effectively promoting ecological sustainability. However, all the financial development indicators considered foster environmental sustainability through the channel of human capital in the short run. The results further showed bidirectional causality among green finance, financial development indicators, and environmental sustainability.

Using panel data from the World Development Indicators and the Organisation for Economic Co-operation and Development (OECD), Asif et al. (2025) investigated the contributions of energy use, digitisation, internationalisation, and green finance to the environmental sustainability of G20 countries between 2004 and 2023. The findings showed that green finance, digitalisation, globalisation, and energy use significantly and positively correlated with ecological sustainability. The study offered new insights into enhancing green market systems in G20 countries to enhance low-carbon technology exchange for emissions reduction.

Zhang & Xi (2024) investigated the implications of green finance and private investments on fossil fuel rents in 20 major carbon-emitting countries between 2000 and 2020. The study employed the least-squares method to estimate an autoregressive distributed lag (ARDL) model. The findings showed that green finance significantly reduced fossil fuels, while private investments exacerbated the problem of fossil fuel rents. In particular, a 1% increase in green finance reduces fossil fuel rents by 0.37% in the short term and 0.40% in the long term. On the contrary, the results showed that a 1% increase in private investment leads to a 0.17% increase in short-term and 0.23% rise in long-term fossil fuel rents. The recommendations proffered by the study, based on its findings, include enhancing green bond initiatives, improving ESG reporting, and digitalising green financial markets, among others.

Leveraging the Granger causality test, Çıtak & Hoş (2024) explored the interaction between green finance and environmental sustainability in the G7 countries, comprising Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, from 1990 to 2021. The findings showed evidence of bidirectional causality between green finance and environmental sustainability in Germany and the USA. However, the results showed that Canada witnessed a unidirectional causality between green finance and environmental sustainability. On the other hand, the results showed that there is no causal relationship between green finance and environmental sustainability in France, Italy. Overall, the study concludes that green finance is an essential critical enabler of an environmentally sound global economy.

Udeagha & Muchapondwa (2023) empirically explored the combined effects of green finance and financial technology (fintech) on environmental sustainability in the BRICS nations from 1990 to 2020. The results for the BRICS economies showed that green finance, fintech and energy innovation improved environmental sustainability. However, natural resources rent and economic growth (GDP) undermine environmental quality.

Additionally, the results showed bidirectional causality among CO2 emissions, GFN, green finance, green fintech, and NRR. However, GDP was found to exhibit unidirectional causality with CO2 emissions. Based on

the empirical findings, the study recommends that BRICS countries accelerate the development of green financial products and enhance the capacity of banks and financial institutions to offer green credit facilities.

Using data from Chinese cities between 2006 and 2022, Wu, Liu & Cai (2024) investigate the relationship between green finance and carbon emission efficiency in China. Their findings indicate that green finance plays a significant role in improving carbon emission efficiency. This effect is influenced by a dual threshold, which varies with the regional level of economic development. Additionally, regional innovation serves as a key pathway through which green finance impacts carbon emission efficiency. The sensitivity of carbon emission efficiency to the green finance index follows an inverted U-shaped pattern, with green support being particularly impactful across the eco-friendly finance sub-dimensions. Overall, these results offer important theoretical support for the role of green finance in enhancing carbon efficiency and provide valuable guidance for developing effective policy measures.

METHODOLOGY

Research Design

This study employed an ex-post facto research design, given that it relied on secondary data, which cannot be manipulated. Pástor, Stambaugh & Taylor (2022) posit that the use of ex post facto research has been described in the extant literature as ideal for examining cause and effect relationships between economic and financial variables.

Model Specification

This study closely follows the works of Asif et al. (2025), Çıtak & Hoş (2024) and Wu et al. (2024) with some improvements. Essentially, the model was augmented by the introduction of international finance received for clean energy, total donations received for biodiversity conservation, and international financial support for green infrastructure to measure green finance in the WAMZ. The functional specifications of the models are presented as follows:

$$CO2E = f (IFCE, TDBC, IFGI, TCGR) \qquad (3.1)$$

Where: CO2E = Annual CO2 emissions, which measure environmental sustainability, IFCE = International finance received for clean energy, TDBC = Total donations received for biodiversity conservation, IFGI = International financial support to green infrastructure, TCGR = Technical cooperation grants,

Following the nature of this study, the static panel models involving pooled, fixed effects and random effects are specified accordingly:

Pooled Regression Model

$$CO2E_{it} = \beta_0 + \beta_1 IFCE_{it} + \beta_2 TDBC_{it} + \beta_3 IFGI_{it} + \beta_4 TCGR_{it} + \square_{it} \qquad (3.2)$$

Where: β_0 = Intercept, $B_i - \beta_3$ = slope parameters, $\square_{it}$ = error term, $i = 1, . . ., N.$ $t = 1, . . ., T,$ i = cross sectional units including the selected countries in the WAMZ and t = time dimension (2004 to 2023)

Fixed Effects Models

The specification of the fixed effects model for this study is consistent with the standard model set-up of Mundlak (1978) and Wallace & Hussain (1986). The model is specified as follows:

$$CO2E_{it} = \beta_0 + \beta_1 IFCE_{it} + \beta_2 TDBC_{it} + \beta_3 IFGI_{it} + + \beta_4 TCGR_{it} + U_i + \square_{It} \qquad (3.3)$$

Where: U_i = fixed effects (individual effects)

The null and alternative hypotheses tested under the fixed effects models are provided as follows:

$H_0: U_1 = U_2 = U_3 = U_4 = U_5 = 0$

$H_1: U_1 \neq U_2 \neq U_3 \neq U_4 \neq U_5 \neq 0$ (3.4)

Random Effects Models

The random effects model followed the original specification of Balestra and Nerlove (1966). The formal specification of the random effects is provided as follows:

$$CO2E_{it} = \beta_0 + \beta_1 IFCE_{it} + \beta_2 TDBC_{it} + \beta_3 IFGI_{it} + \beta_4 TCGR_{it} + U_i + v_{it}$$ (3.5)

Where: U_i= Random effects (individual effects) and v_i= Remainder disturbance term

Nature and Source of Data

This study utilised panel data comprising cross-sectional units and time series. Specifically, the cross-sectional units include the countries in the WAMZ, such as Nigeria, Ghana, Sierra Leone, The Gambia, Liberia, and Guinea. On the other hand, the time series includes data on CO2 emissions, international finance received for clean energy, total donations received for biodiversity conservation and international financial support to green infrastructure. The datasets were obtained from the Organisation for Economic Co-operation and Development (OECD), the United Nations (UN), the International Renewable Energy Agency (IRENA), and the Global Carbon Budget over the period 2004-2023.

Data Analysis Techniques

The Pooled Regression Model For The Panel Data Was Analysed Using Ordinary Least Squares (Ols). This Approach Assumes Homogeneous Intercepts And Common Slope Coefficients Across Time And The Member Countries Of Wamz. Additionally, The Fixed Effects Model Was Estimated Utilising The Least Squares Dummy Variable (Lsdv) Estimator. Mundlak (1978) & Wallace And Hussain (1986) Suggested Estimating Fixed Effects, Particularly In One-Way Error-Component Models, When Heterogeneous Intercepts Exist Across Individual Units But Slope Coefficients Are Similar. The Random Effects Model Was Also Estimated Using The Maximum Likelihood (Ml) Estimator, Following Balestra & Nerlove's (1966) Prescription. In The Fixed-Effects Model, The Individual Effects Are Treated As Random, Aligning With Mundlak (1978), Who States That The Random-Effects Model Assumes Regressors Have Random, Exogenous Individual Effects. The Im-Pesaran-Shin's (Ips, 2003) Panel Unit Root Test Was Employed In This Study, Which Assumes Individual Unit Root Process. As A First-Generation Of Panel Unit Root Test, The Ips Integrates Residual Serial Correlation And Heterogeneity Of The Dynamics And Error Variances Across Groups. Additionally, The Hausman (1978) Test Was Employed As The Postestimation Test To Decide The Appropriate Model Between The Two Competing Models Of Fixed Effects And Random Effects Models.

RESULTS AND DISCUSSION

Descriptive Statistics

The descriptive statistics for each variable are summarised in Table 1.

Table 1: Summary of descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2E	138	21400000	41200000	300448	148000000
IFCE	138	55300000	182000000	0	1280000000
TDBC	138	20800000	33300000	0	234000000

IFGI	138	206000000	249000000	50000	1430000000
TCGR	138	149000000	137000000	1050000	677000000

Source: SATA 17 Output

Table 1 presents summary statistics for five variables (CO2E, IFCE, TDBC, IFGI, and TCGR) based on 138 observations each. The results reveal key insights into the average, variance, and range of each variable. Specifically, annual CO2 emissions averaged 21400000 metric tonnes, with values ranging from 300448 to 148,000,000 metric tonnes. The small minimum value compared to the maximum highlights significant inequality in emission levels. The high standard deviation of 41200000, relative to the mean of 21400000, indicates substantial volatility, with some countries emitting very high amounts and others very low during the study period. The results show that international finance received for clean energy averaged \$55,300,000. The amount received from donor agencies for clean energy ranged from 0 to \$1,280,000,000,000, indicating that some countries received nothing during certain study periods. The standard deviation of 182000000 is more than three times the mean, indicating very high dispersion in the international finance received for clean energy. The results further reveal that total donations received for biodiversity conservation averaged \$20,800,000. The variability of observations from the minimum value of \$0 to the maximum of \$234,000,000 highlights inconsistent patterns in total donations for biodiversity conservation. Additionally, the average values of international financial support to infrastructure and technical cooperation grants are \$206,000,000 and \$149,000,000, respectively. This underscores the increasing focus on physical infrastructure development, possibly due to the pronounced infrastructure gap in WAMZ member countries. The observations for these two variables show large gaps between minimum and maximum values, indicating significant disparities across observations.

Unit Root Test

The results are summarised in Table 2.

Table 2: Summary of IPS panel unit root test results

Variable	Z-t-tilde-bar stat. at levels	Z-t-tilde-bar stat. at 1st difference	Order of integration
CO2E	-6.258 (0.0000)	-	I(0)
IFCE	-5.734 (0.0000)	-	I(0)
TDBC	-4.773 (0.0000)-	-	I(0)
IFGI	-7.488 (0.0000)	-	I(0)
TCGR	-2.6360 (0.0042)	-	I(0)

Source: SATA 17 Output

Note: Figures in brackets denote the corresponding p-values of the test statistics

The null hypothesis stating that all panels have a unit root was tested against the alternative that some panels are stationary, using the Z-t-tilde-bar statistics and their p-values. The findings indicate that all variables are stationary, as their p-values are below 0.05. Consequently, the null hypothesis that all panels contain a unit root is rejected at the 5% significance level. This finding implies that the variables are integrated of order zero, I(0).

The evidence of a stationary process in the panels necessitated the estimation of static panel data regression models, including pooled OLS (POLS), fixed-effects, and random-effects models.

Model Estimation

Table 3: Summary of fixed effects (FE) and random effects (RE) results

Dependent variable: CO2E		
Variables	FE	RE
IFCE	0.000816	-0.00262
	(0.00300)	(0.0129)
TDBC	-0.0269	-0.242***
	(0.0197)	(0.0824)
IFGI	0.0206***	0.0823***
	(0.00494)	(0.0192)
TCGR	0.0279**	0.117***
	(0.0111)	(0.0350)
Constant	13560000***	-7825000**
	(1226000)	(3445000)
F-test(u_i=0)	476.21	
Prob.>F-(u_i=0)	0.0000	
Chi-square(var(u_i=0))		191.58
Prob.> chi2(var(u_i=0))		0.0000
Observations	138	138
R-squared	0.5804	0.5902
Number of crossid	6	6

Source: SATA 17 Output

Note: Standard errors in parentheses and *** $p<0.01$, ** $p<0.05$, * $p<0.1$ denote significant at 1%, 5% and 10% respectively

Table 4.3.1: Hausman test results

Variable	Fixed	Random	Difference	Std. err.
IFCE	.000816	-.0026222	.0034382	.041389
TDBC	-.0268656	-.2415194	.2146537	.131789
IFGI	.0205564	.0822703	-.0617139	.017850

TCGR	.027905	.117302	-.089397	.056419
chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)		= 4.72		
Prob > chi2 = 0.1753				

Source: STATA 17 output

The Hausman test results in Table 4.3.1 informed the choice between fixed- and random-effects models. Since the chi-square probability value (0.1753) exceeds 0.05, the random effects model is preferred for analysis. The estimated random-effects model indicated that international funding for clean energy reduces annual CO_2 emissions. Although this finding is not statistically significant at the 5% level, it suggests that donor agency funding for clean energy may help reduce CO_2 emissions across WAMZ member countries. The insignificant negative impact of international funding for clean energy on CO2 emissions corroborates the finding of Marashdeh & Khataybeh (2025), who reported that green finance has not effectively promoted environmental sustainability. But, it is contrary to the findings of Wu, Liu & Cai (2024), who reported that green finance plays a significant role in improving carbon emission efficiency, with this effect influenced by a dual threshold that varies with regional levels of economic development. At the same time, the results showed that total donations directed towards biodiversity conservation significantly reduced annual CO_2 emissions in the WAMZ during the study period. This finding is consistent with the a priori expectation and with the findings of Asif et al. (2025) and Zhang & Xi (2024), who reported that green finance significantly reduced emissions from fossil fuels and improved environmental sustainability. This finding shows that the financial resources used for biodiversity conservation are being managed effectively. It also suggests that donor-funded projects, such as reforestation, habitat restoration, protected area management, and anti-deforestation efforts, are delivering meaningful environmental benefits in the WAMZ. However, the findings reveal that international financial support aimed at infrastructure development and technical cooperation grants significantly increased annual CO_2 emissions. This finding underscores the inadequate enforcement of environmental safeguards, impact assessments, and monitoring systems for infrastructure projects financed by international partners in the WAMZ. It also indicates that infrastructure projects funded by external donors often lack sufficient focus on low-carbon technologies or climate-resilient standards. The R-squared of 0.5902 showed that about 59.02% of the total variations in CO2 emissions are jointly explained by the changes in the green finance indicators. This suggests that the estimated random effects model is a good fit. Additionally, the results showed that the probability value (0.0001) of the Chi-square statistic (191.58) is less than 0.05, confirming the significance of the estimated random effects model at the 5% level. This also supports the model's reliability for prediction and policymaking.

CONCLUSION AND RECOMMENDATIONS

The thrust of this study is the empirical investigation of the effect of green finance on environmental sustainability, with a focus on annual CO2 emissions. The findings showed that international financing for clean energy adversely affected annual CO2 emissions. Although this finding is not significant, it suggests that funds available for clean energy initiatives could help tackle CO2 emissions when properly utilised. The results showed that total donations for biodiversity conservation significantly reduced annual CO2 emissions, indicating that funding for biodiversity conservation is an essential enabler of environmental sustainability in the WAMZ. Additionally, the results showed that international financial support for infrastructure and technical cooperation grants positively and significantly affected annual CO2 emissions. This finding indicates that these funding sources have not translated into environmental sustainability, which may be linked to poor institutional quality, managerial inefficiency, and a limited focus on low-carbon technologies in the funds' investments. Given the findings, it is concluded that green finance, especially total donations for biodiversity conservation, plays a critical role in environmental sustainability in the WAMZ. Another conclusion drawn from the findings is that, contrary to expectation, international financial support for infrastructure and technical cooperation grants has undermined the goal of environmental sustainability in the WAMZ. Based on the findings, it is recommended that policymakers in the WAMZ should strengthen project appraisal frameworks and prioritise high-impact renewable energy initiatives to ensure clean energy financing is effectively utilised and results in significant CO2 emission reductions. It is also recommended that governments in the WAMZ

should enhance their institutional frameworks for conservation management to secure increased funding through international grants and climate funds dedicated to environmental sustainability in the region.

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