Blueprint Academic Publishers

Journal of Business, Economics and Management Research Studies
Journal ISSN: 3005-2173
4(3)
Received: October 03, 2026
Accepted: October 30, 2026
Published: November 04, 2026

Carbon Credits and Financial Sustainability of Firms Listed on Nairobi Securities Exchange, Kenya: The Moderating Effect of Regulatory Framework

Atieno Macrean Eunice, Ayuma Caroline and Tanui Emmanuel

Department of Finance and Accounting, School of Business, Economics and Management Sciences, University of Eldoret, Kenya

Abstract

Carbon-credit markets provide firms with opportunities to participate in activities that reduce or remove greenhouse gas emissions while potentially creating financial value. However, the financial benefits of carbon credits may depend on the regulatory environment in which firms operate. This study examined the effect of carbon credits on the financial sustainability of firms listed on the Nairobi Securities Exchange (NSE), Kenya, and assessed the moderating effect of the regulatory framework on that relationship. Financial sustainability was measured using return on assets (ROA), while carbon credits were measured using carbon emission intensity, carbon credits traded or retired, and expenditure on carbon-offset project audits. Anchored on the positivist philosophy, the study adopted an explanatory longitudinal design and analyzed secondary data from 43 NSE-listed firms over 2016–2025, yielding 430 firm-year observations. Hierarchical panel regression was conducted in R, with the Hausman test supporting random-effects estimation. The results showed that carbon credits had a positive and statistically significant effect on financial sustainability ($\beta = 0.2663$, $p < 0.001$), and exhibited the strongest bivariate association with financial sustainability among the study variables ($r = 0.714$, $p < 0.001$). The regulatory framework also had a positive and significant direct effect on financial sustainability ($\beta = 0.2212$, $p < 0.001$). However, the interaction between carbon credits and the regulatory framework was negative and statistically significant ($\beta = -0.9385$, $p = 0.0017$), indicating that the regulatory framework significantly moderated specifically, weakened the carbon credits–financial sustainability relationship. The final model explained 88.19% of the variation in financial sustainability ($R^2 = 0.8819$). The findings imply that although carbon credit participation remains financially beneficial at all levels of regulatory intensity, escalating compliance and verification costs erode its marginal financial gains. The study recommends that policymakers streamline monitoring, reporting and verification requirements so that regulation safeguards environmental integrity without imposing disproportionate participation costs, and

that firms integrate carbon credit strategies into core operations rather than treating them as symbolic compliance.

Keywords: Carbon Credits, Regulatory Framework, Financial Sustainability, NSE

Correspondence: macreanatieno@gmail.com

Copyright © 2026 Atieno et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY).

Funding: The author received no financial support for the research, authorship and/or publication of this article

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials or upon reasonable request.

Competing interests: The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Introduction

Firms increasingly face pressure to reduce greenhouse-gas emissions while maintaining financial sustainability (Aibar – Guzman et al., 2024). Carbon-credit markets provide the mechanism through which firms in different sectors can support emissions reduction or removal activities and participate in the exchange of verified carbon units. A carbon credit commonly represents one metric tons of carbon-dioxide equivalent that has been reduced or removed (Trouwloonet al., 2024). Under carbon credit arrangement, firms, governments and project developers buy credit through the acquisition, trading or retirement of credits. Firms buy carbon credits that are commensurate to the removal of greenhouse gas emissions from the atmosphere. The carbon trading can be done either on voluntary carbon markets or within the compliance mechanism availed by different jurisdictions (Wetterberg et al., 2024, 2024; Probst et al., 2024)

In the recent past, carbon credits has become an important global instrument for addressing climatic changes and also creating financial value for economic activities of listed firms. Through the trading of verified emissions reductions, firms can get access to carbon markets, support environmental initiatives and improve their financial sustainability. Whereas participation in carbon trading may translate to improved financial sustainability, the financial benefits may depend on factors such as quality of traded carbon credits, prevailing market conditions, project development processes and the costs that are incurred during participation in the trade. Other costs are for verifying emissions reduction, mobilizing the required documentation and meeting the policy requirements. These factors help in determining whether the benefits realized from carbon credit activities may have more weight compared to the resources availed to the activities (Martielli et al., 2025; Schmuck et al., 2025).

Africa has increasingly emerged as an important player in carbon markets. This is due to its natural resources and the opportunities it offer for renewable energy, conservation of forests, improved cooking technologies and other emissions

reduction projects (Yeboah et al., 2024; Moyo, 2024). In Kenya, the Climate Change (Carbon Markets) Regulations, 2024 introduced a new national legal framework for trade in the carbon markets. The new regulations set the engagement terms for carbon credit activities in the country. The engagements involve project approval, monitoring, verification and benefit sharing. Understanding how regulatory arrangements influence the financial outcomes associated with carbon credits is therefore relevant to firms listed on the NSE (Njoroge, 2025; Adamolekun, Li and Xu, 2025)

The regulatory environment is a key component since it formulates the policies that govern carbon credits trading in the carbon market. Regulatory framework ensures that credit trading is authorized and whether the transactions are monitored and finally verified (Chuang and Liu, 2025; NEMA 2024). The benefit of having effective regulation is so that the credibility of the markets can be strengthened. They also ensure that the integrity of the environment is protected, increasing the confidence among shareholders and investors. Since compliance procedures are always likely to increase administrative and operational costs incurred by participating firms, the financial benefits derived from carbon credits activities may vary according to the regulatory conditions under which firms operate (Delacote et al., 2025; Datt, Luo and Segara, 2025) .

Previous scholars established mixed results between carbon credits and financial sustainability. Studies by (Martielli et al., 2025; Salvi et al., 2025) exhibited a positive relationship between carbon credits and financial sustainability, Arliea et al. (2025) showed a negative relationship. Although previous research has examined carbon-credit participation and corporate financial performance, the role played by regulatory framework in shaping this relationship was still worth exploring especially in firms listed on NSE. This study addressed that concern by examining the relationship between carbon credits and financial sustainability. It further sought to establish whether regulatory framework played a moderating role in the relationship between carbon credits and financial sustainability.

Theoretical Review

The below theories were employed to guide the research. They include, Tripple Bottom Line Model and Green Growth Theory.

Triple Bottom Line Model

The Triple Bottom Line (TBL) perspective, associated with Elkington (1997), considers organizational performance in terms of economic, environmental and social outcomes. It extends the assessment of business success beyond financial returns alone by recognizing that firms also have responsibilities relating to the environment and society. Applied to carbon credits, the perspective suggests that firms may support emissions reduction activities while seeking to maintain their financial viability and meet stakeholder expectations (Oppon et al., 2024).

In this study, the TBL perspective provides a basis for examining whether carbon-credit activities are associated with financial sustainability. It also helps explain why environmental initiatives should be considered alongside the economic consequences of participating in carbon markets. The perspective is relevant because carbon credit activities may generate environmental benefits. However, their financial contribution depends on whether those activities are

managed in a manner that supports the firm's economic performance.

Green Growth Theory

Green Growth Theory proposes that economic development and environmental improvement can be pursued together through investment, innovation and policies that reduce environmental pressures while supporting productive activity (OECD, 2025). Carbon credits provide a market-based mechanism through which emissions reductions or removals may be recognized and financed. From this perspective, carbon-credit activities may support environmental objectives while creating opportunities for firms to participate in emerging markets. The theory informs this study by providing a basis for examining the relationship between carbon credits and financial sustainability. It also supports the examination of regulatory framework as a moderator because rules governing carbon markets may influence the costs, credibility and financial benefits of participation in the carbon markets (Stek, 2025).

Empirical Review

Carbon Credits and Financial Sustainability

In China, Zheng (2024) examined the impact of green credit and carbon emission reduction in the listed manufacturing industry, employing SWOT and PEST analyses on data from the China Carbon Accounting Database. The study concluded that green credit promotes carbon reduction among listed firms by stimulating investment, reducing costs, improving corporate image and attracting policy support, although funding constraints, complex application processes and market risks remain obstacles. The study recommended that governments introduce more explicit green credit policies and emission reduction targets to channel funds into energy-saving and environmentally friendly projects.

In Italy, Martielli (2024) examined how carbon credits can improve financial performance through a systematic literature review of 18,509 publications drawn from Web of Science and Scopus (2014–2024), anchored on stakeholder and institutional theories. The findings confirmed that carbon emissions have a detrimental effect on financial performance; however, this negative impact can be mitigated by adopting carbon offsets and credits, which moderate the emissions–performance relationship. The study concluded that carbon credits have a significant positive impact on financial performance and recommended that managers implement sustainable practices that enhance both environmental outcomes and overall financial performance.

At the regional level, Emenekwe et al. (2022) analyzed the nexus between financial development, economic growth and carbon dioxide emissions for 37 Sub-Saharan African countries using panel data (2000–2016) and pooled mean group ARDL and dynamic GMM estimators. The findings indicated that financial development dimensions significantly reduced CO_2 emissions in the region and, in turn, supported financial sustainability. Using a panel fixed-effects regression, Hou et al. (2025) examined the relationship between carbon emissions and firm performance among 111 South African companies (2010–2022), guided by the natural resource-based view, with ROA measuring short-term performance and Tobin's Q long-term performance. The results revealed significant correlations between greenhouse gas emissions and financial performance metrics, supporting the paradigm that environmental and financial performance

are linked, and recommended that policymakers encourage carbon reduction targets, carbon pricing and sustainable supply chain practices.

In Uganda, Okillong and Luwedde (2023) investigated the effect of industrialization and financial development on carbon emissions using ARDL time-series analysis (1990–2020) within an Ecological Kuznets Curve framework. Financial development and industrialization had positive and significant long-run effects on CO_2 emissions, prompting recommendations for sustainable trade and climate policies, including carbon tariffs and incentives for low-carbon production.

In Japan, Nawaz et al. (2025) evaluated the economic growth–carbon emissions nexus using ARDL bounds testing on data from 1990 to 2020. The findings confirmed that aggregate economic growth significantly accelerates carbon emissions, and concluded that shifting capital toward eco-efficient energy assets mitigates climate transition risks and safeguards long-term environmental and financial sustainability.

More recently, Martielli et al. (2025) analyzed a global sample of listed companies that adopted carbon credits between 2019 and 2023 using pooled OLS estimation, finding that mitigating carbon emissions through carbon credits has a positive influence on financial performance. Taken together, the empirical literature points predominantly to a positive carbon credits–financial performance nexus, although the strength of the relationship varies across markets and regulatory contexts. The present study extends this evidence to firms listed on the NSE, Kenya. Accordingly, the following null hypothesis is posed:

H_{01}: *Carbon credits have no significant effect on the financial sustainability of firms listed on the NSE, Kenya.*

The Moderating Role of Regulatory Framework

Regulatory frameworks refer to rules, laws and guidelines issued by governing bodies to manage and control the operations of organizations and ensure compliance with legal and ethical standards (Gautam et al., 2024). Such frameworks are essential for maintaining order across sectors by defining acceptable conduct, promoting accountability, minimizing risks and protecting public interest (Alanoca et al., 2025; Yi & Latiff, 2024). In response to growing concerns over environmental impact and financial vulnerabilities, researchers have increasingly examined the influence of regulatory frameworks on sustainability outcomes.

Ahlström and Monciardini (2022) examined the regulatory dynamics of sustainable finance in the European Union through a longitudinal document analysis (2009–2019) and semi-structured interviews, finding that successful regulatory dynamics depend on a hybrid configuration of social constituents supporting reform, and on understanding the inherent contradictions and limitations of sustainable finance as a means of transformative change.

Setyowati (2023) examined the governance of sustainable finance in Indonesia through 33 structured stakeholder interviews and documentary analysis, finding relatively high procedural compliance with sustainable finance obligations but persistent implementation challenges, including regulatory frameworks of limited effectiveness in giving clear direction. The study concluded that effective governance of sustainable finance requires multiple, mutually reinforcing policy approaches.

Jeriji and Nasfi (2023) investigated the value relevance of mandatory sustainability reporting assurance (SRA) using an OLS panel model (2007–2018) covering 88 JSE-listed South African firms and 83 SBF120 French firms, with Tobin's Q measuring firm value. Mandatory SRA was significantly and positively associated with firm value, implying that assurance regulations strengthen firm legitimacy, reduce information asymmetry and mitigate agency problems.

In the East African context, Mweta (2024) investigated the regulatory framework and financial performance of publicly cross-listed firms in the EAC region using a ten-year panel (2013–2022) of nine cross-listed enterprises, drawing on agency, stakeholder, resource dependence, stewardship and institutional theories. The regulatory framework significantly influenced the relationship between governance mechanisms (executive compensation, executive shareholding, auditor dominance) and ROA, although the regulatory compliance index did not significantly affect all governance–performance relationships, underscoring the contingent nature of regulatory effects.

Recent evidence further clarifies how regulation conditions the financial payoff of carbon-related strategies. Martielli et al. (2025), in their global study of carbon-credit-adopting listed firms (2019–2023) grounded in the resource-based view and legitimacy theory, demonstrated that the positive effect of carbon credits on financial performance is contingent on the quality of the institutional and governance environment: CSR strategy and corporate governance practices significantly moderated the carbon credits–financial performance relationship, implying that market-negotiable climate instruments yield financial benefits only when embedded in credible governance and accountability structures

In China, Liu et al. (2025) employed panel regressions on 1,753 firm-year observations of A-share listed companies (2013–2022) and found that carbon information disclosure significantly enhances firm value, with green innovation positively moderating this relationship; crucially, environmental regulation further strengthened that moderating effect, acting as a lever that amplifies the financial benefits of carbon disclosure. However, their threshold analysis revealed an important nuance: under low environmental regulation, carbon disclosure failed to enhance firm value, while excessively high regulation imposed compliance pressures that likewise constrained the benefits suggesting that the regulatory effect is non-linear and contingent on regulatory intensity.

On the other hand, Wendy (2026), using a fixed-effects panel of 250 Forbes Global 2000 companies (2020–2023) focused on sectoral and regulatory heterogeneity, found that while direct (Scope 1 and 2) emissions significantly reduced profitability, regulatory stringency did not significantly moderate the emissions such as profitability relationship a result attributed to firms' anticipatory internalization of regulatory costs and to enforcement gaps in emerging economies, where ambitious formal frameworks coexist with weak implementation.

Taken together, the literature reveals that regulatory frameworks can either amplify or dampen the financial returns to carbon-related strategies, depending on regulatory design, enforcement intensity and institutional context. Evidence specific to carbon credits among listed firms in Kenya — where the Climate Change (Amendment)

Act, 2023 and the Climate Change (Carbon Markets) Regulations, 2024 (effective 17 May 2024) have only recently operationalized carbon trading remains scarce. This study addresses that gap by testing whether the regulatory framework moderates the carbon credits–financial sustainability relationship among NSE-listed firms. Accordingly, the following null hypothesis is posed:

H_{02}: *Regulatory framework has no moderating effect on the relationship between carbon credits and financial sustainability of firms listed on the NSE, Kenya.*

Conceptual Framework

The study examined carbon credits as the independent variable. Financial sustainability was the dependent variable and regulatory framework moderated the relationship.

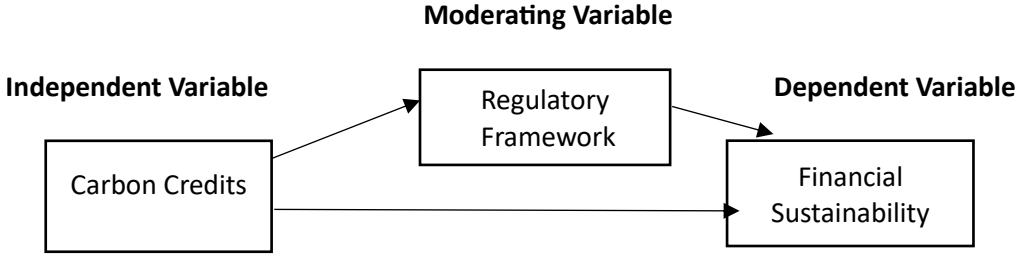


Figure 1: Conceptual Framework for the study
Source: Research (2026)

Methodology

This study was anchored on the positivist paradigm, which holds that reality is objective, measurable and independent of human perception (Park et al., 2020). Positivism was appropriate because the study variables such as financial sustainability, carbon credits and regulatory compliance are quantifiable, and because the paradigm supports hypothesis testing of causal and moderating relationships through regression analysis, with findings that can be replicated in similar contexts (Yong et al., 2021). The study adopted descriptive and explanatory longitudinal designs: the explanatory design established the effect of carbon credits on financial sustainability and the moderating role of the regulatory framework, while the longitudinal design tracked the same firms over time (Blair et al., 2023; Sidharth, 2023).

The study was conducted on firms listed on the Nairobi Securities Exchange (NSE) in Nairobi, Kenya. The NSE is Kenya's primary securities market and brings together firms from diverse sectors operating under a common regulatory environment overseen by the Capital Markets Authority (CMA) and the National Environment Management Authority (NEMA), providing a suitable institutional setting for the study (NSE, 2024). The target population comprised the 65 firms listed on the NSE as at 31st December 2025, chosen because they publish audited financial statements and are subject to mandatory CMA and NSE disclosure requirements (Ibrahim, 2024). To qualify for inclusion, a firm had to have been in continuous operation and quoted on the NSE throughout 2016–2025. Firms listed after 2016, delisted or suspended before 2025, or with missing data and

inconsistent carbon credit or regulatory compliance disclosures were excluded. This left 43 firms and a balanced panel of 430 firm-year observations over the ten-year period.

The dependent variable, financial sustainability, was measured using Return on Assets, computed as net income divided by total assets (Gleißner et al., 2022; Karadayi, 2023). The independent variable, carbon credits, was measured using carbon emission intensity — the negative natural logarithm of Scope 1 and Scope 2 emissions scaled by total revenue, together with the number of carbon credits traded or retired — and project audits captured through expenditure on afforestation and reforestation (Choube et al., 2024; Motalingoane et al., 2026). The moderating variable, regulatory framework, was measured using an Extended Producer Responsibility (EPR) compliance index ($\Sigma X_i/N$, where $X_i = 1$ if a firm complies with a disclosure item and 0 otherwise) and the CMA Code of Corporate Governance compliance index (Mishra & Kumar, 2023; Tumu et al., 2023). Firm size (natural logarithm of total assets) and firm age (natural logarithm of years since incorporation) were included as covariates (Buer et al., 2020; Li et al., 2022).

Data were collected from secondary sources including firms' annual reports, audited financial statements, sustainability reports and publications of regulatory institutions (CMA, NEMA, World Bank) covering financial sustainability indicators, carbon credit activities and regulatory compliance for 2016–2025. The main instrument was a researcher-developed data extraction schedule, ensuring accuracy and consistency across firms and years (Hu & Xu, 2023).

The study used descriptive statistics (means, standard deviations, frequency distributions) and inferential statistics, aided by R software. Pearson correlation coefficients established the strength and direction of associations, while hierarchical random-effects regression tested the direct effect of carbon credits on financial sustainability and the moderating effect of the regulatory framework, with the choice between fixed and random effects guided by the Hausman specification test. Feasible Generalized Least Squares estimation addressed any violations of regression assumptions. Results were presented in tables and figures.

Before estimation, the data were tested for linearity (Ramsey RESET), normality (Shapiro–Wilk), heteroscedasticity (Breusch–Pagan), multicollinearity (VIF) and autocorrelation (Durbin–Watson), while stationarity was confirmed using the Levin–Lin–Chu panel unit root test. The choice between fixed and random effects was guided by the Hausman specification test, with random effects applied where $p > 0.05$ (Le Gallo & Sénégas, 2023).

A hierarchical regression approach was used, adding variables at successive steps and using ΔR^2 to establish whether each addition significantly improved explained variance (Gao, 2024). All models were estimated as random-effects panel models following the Hausman test:

Model 1 (Baseline — covariates only):

$$FS_{it} = \beta_0 + \beta_1 FIRMSIZE_{it} + \beta_2 FIRMAGE_{it} + \varepsilon_{it}$$

Model 2 (Direct effect of carbon credits — tests H_{01}):

$$FS_{it} = \beta_0 + \beta_1 CC_{it} + \beta_2 FIRMSIZE_{it} + \beta_3 FIRMAGE_{it} + \varepsilon_{it}$$

Model 3 (Moderation model — tests H_{02}):

$$FS_{it} = \beta_0 + \beta_1 CC_{it} + \beta_2 RF_{it} + \beta_3 (CC_{it} \times RF_{it}) + \beta_4 FIRMSIZE_{it} + \beta_5 FIRMAGE_{it} + \varepsilon_{it}$$

Where: FS = Financial Sustainability (DV); CC = Carbon Credits (IV); RF = Regulatory Framework (moderator); FIRMSIZE, FIRMAGE = covariates; β_0 = constant; $\beta_1 \ldots \beta_5$ = parameters of estimate; ε = error term; i = firm; t = year. To mitigate omitted-variable bias, the estimated models retained the remaining firm-level green finance constructs as ancillary controls consistent with the focus of the study, only the focal coefficients are reported and interpreted.

Results and Discussion

Descriptive Statistics

Table 1 presents the descriptive statistics for the study variables.

Table 1: Descriptive Statistics of Study Variables

Variable	Mean	Median	SD	Min	Max
Financial Sustainability (FS)	0.3229	0.3272	0.0708	0.1159	0.5018
Carbon Credits (CC)	0.6477	0.6448	0.1464	0.2721	0.9978
Regulatory Framework (RF)	0.4965	0.6611	0.1459	0.0442	0.9983
Firm Size (KES Billions)	120.3256	105.7338	66.4958	25.5566	501.6593
Firm Age (Years)	71.2907	67.0000	24.1131	17.0000	129.0000

Source: *Research Data (2026)*

Financial sustainability recorded a mean of 0.3229 (SD = 0.0708) and a median of 0.3272, with values ranging from 0.1159 to 0.5018. Carbon credits had a mean of 0.6477 (SD = 0.1464) and a median of 0.6448, ranging from 0.2721 to 0.9978. The regulatory framework index recorded a mean of 0.4965 (SD = 0.1459) and a median of 0.6611, with values ranging from 0.0442 to 0.9983. Regarding the control variables, firm size averaged KES 120.33 billion (SD = 66.50 billion), ranging from KES 25.56 billion to KES 501.66 billion, while firm age had a mean of 71.29 years (SD = 24.11), with a range of 17 to 129 years.

Pre-Estimation Diagnostic Tests

Before panel estimation, the data were subjected to a battery of specification and assumption tests, summarised in Table 2.

Table 2: Summary of Pre-Estimation Diagnostic Tests

Test	Statistic	p-value	Conclusion
Ramsey RESET (linearity)	1.3862	0.2512	Correct functional form
Shapiro–Wilk: FS	W = 0.9959	0.3274	Normal
Shapiro–Wilk: CC (Yeo–Johnson)	W = 0.9938	0.0750	Normal
Shapiro–Wilk: RF (Yeo–Johnson)	W = 0.9945	0.1255	Normal
Variance Inflation Factors	1.007 – 1.035	—	No multicollinearity
Breusch–Pagan: CC	0.0020	0.9646	Homoscedastic
Breusch–Pagan: RF	0.4479	0.5034	Homoscedastic
Durbin–Watson	1.9983	0.4888	No autocorrelation
Levin–Lin–Chu: FS	−20.6498	0.0000	Stationary
Levin–Lin–Chu: CC	−18.7086	0.0002	Stationary
Levin–Lin–Chu: RF	−15.9946	0.0000	Stationary
Hausman test	$\chi^2(8) = 10.858$	0.2099	Random effects preferred

Source: *Research Data (2026)*

The Ramsey RESET statistic (1.3862, p = 0.2512) failed to reject the null of correct functional form, validating the linear specification. Following Yeo–Johnson transformation of carbon credits and regulatory framework, Shapiro–Wilk statistics confirmed normality of all relevant variables. Variance inflation factors (all below 1.04, far under the conventional threshold of 5) ruled out multicollinearity; Breusch–Pagan tests confirmed homoscedasticity; and the Durbin–Watson statistic of 1.9983 indicated the absence of serial autocorrelation. Levin–Lin–Chu panel unit-root tests rejected the null of a unit root for all study variables, confirming stationarity at levels. Finally, the Hausman test (χ^2 = 10.858, p = 0.2099) failed to reject the consistency of the random-effects estimator; accordingly, all hypothesis-testing models were estimated using random-effects panel regression.

Correlation Analysis

Table 3 presents the Pearson correlation matrix for the study variables. Carbon credits had a strong positive and statistically significant correlation with financial sustainability (r = 0.714, p < 0.001). Regulatory framework was also positively correlated with financial sustainability (r = 0.444, p < 0.001). Firm size exhibited a positive and significant association with financial sustainability (r = 0.697, p < 0.001), whereas firm age had a negative but statistically insignificant correlation (r = −0.061, p > 0.05). Additionally, carbon credits and regulatory framework were positively correlated (r = 0.444, p < 0.001).

Table 3: Pearson Correlation Matrix

	FS	FIRMSIZE	FIRMAGE	CC	RF
FS	1.000				
FIRMSIZE	0.697***	1.000			
FIRMAGE	−0.061	−0.035	1.000		
CC	0.714***	0.477***	−0.068	1.000	
RF	0.688***	0.473***	0.043	0.444***	1.000

***N** = 430; *** **p** < 0.001. **Source:** Research Data (2026)*

Hypothesis Testing

Direct Effect of Carbon Credits on Financial Sustainability

To test H_{01}, a random-effects regression model was estimated to examine the effect of carbon credits on financial sustainability while controlling for firm size and firm age. The results presented in Table 4 are based on a balanced panel of 43 firms observed over 10 years, yielding 430 observations. The findings indicate that the random-effects model was jointly statistically significant (χ^2 = 2391.30, p < 0.001) and explained 85.00% of the variation in financial sustainability (R^2 = 0.8500; adjusted R^2 = 0.8475). Carbon credits had a positive and statistically significant effect on financial sustainability (β = 0.2663, t = 11.0618, p < 0.001). This suggests that an increase in carbon credit intensity is associated with an improvement in firms' financial sustainability. Specifically, a one-unit increase in carbon credits corresponds to a 0.2663-unit increase in financial sustainability, holding firm size and firm age constant.

Regarding the control variables, firm size exhibited a positive and statistically significant effect on financial sustainability (β = 0.0817, t = 11.8600, p < 0.001). This indicates that larger firms tend to demonstrate higher financial

sustainability. However, firm age had a positive but statistically insignificant effect (β = 0.0000, t = 0.0932, p = 0.9258), suggesting that firm age does not significantly explain variations in financial sustainability within the estimated model. Based on the positive and statistically significant coefficient of carbon credits, the null hypothesis (H_{01}), which stated that carbon credits have no significant effect on the financial sustainability of firms listed on the Nairobi Securities Exchange (NSE), is rejected. The findings demonstrate that carbon credits have a positive and statistically significant effect on the financial sustainability of the sampled firms.

Table 4: Random-Effects Estimates of the Direct Effect of Carbon Credits

Oneway (individual) effect Random Effect Model
Balanced Panel: n = 43, T = 10, N = 430
Effects:
Residuals:

Min.	1st Qu.	Median	3rd Qu.	Max.
-0.07397	-0.01780	-0.00184	0.01751	0.13447

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)
Intercept	0.1363	0.0081	16.8745	0.0000
FIRMSIZE	0.0817	0.0069	11.8600	0.0000
FIRMAGE	0.0000	0.0001	0.0932	0.9258
CC	0.2663	0.0241	11.0618	0.0000

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares: 2.1477
Residual Sum of Squares: 0.32216
R-Squared: 0.85
Adj. R-Squared: 0.84751
Chisq: 2391.3 on 7 DF, p-value: < 2.22e-16

FS: *Financial Sustainability;* ***FIRMSIZE****: Firm Size,* ***FIRMAGE****: Firm Age,* ***CC****: Carbon Credit,* ***Source****: Research Data (2026)*

Moderating Effect of Regulatory Framework

To test H_{02}, the interaction between carbon credits (CC) and regulatory framework (RF) was introduced into the random-effects model to determine whether regulatory framework moderates the relationship between carbon credits and financial sustainability. The analysis followed the moderation protocol of Park and Yi (2022) and Rimpler et al. (2025), focusing on the significance and direction of the interaction coefficient and the overall model significance.

The results presented in Table 5 indicate that the random-effects model was jointly significant (χ^2 = 3120.63, p < 0.001), with an explanatory power of 88.19% (R^2 = 0.8819; adjusted R^2 = 0.8788). Carbon credits had a positive and statistically significant effect on financial sustainability (β = 0.4492, z = 6.2541, p < 0.001). Regulatory framework also had a positive and statistically significant effect (β = 0.4713, z = 7.4526, p < 0.001). Regarding the control variables, firm size had a positive and significant effect (β = 0.0647, z = 10.1206, p < 0.001), whereas firm age had a negative but statistically

insignificant effect (β = −0.0001, z = −1.0377, p = 0.2994).

Table 5: Moderating Effect of Regulatory Framework on the Carbon Credits–Financial Sustainability Relationship

Oneway (individual) effect Random Effect Model
Call:
Balanced Panel: n = 43, T = 10, N = 430
Residuals:

Min.	1stQu.	Median	3rd Qu.	Max.
-0.06973	-0.01500	-0.00222	0.01391	0.10232

Coefficients:

	Estimate	Std. Error	z-statistic	Pr (>|z|)
Intercept	0.0684	0.0144	4.7396	0.0000
FIRMSIZE	0.0647	0.0064	10.1206	0.0000
FIRMAGE	-0.0001	0.0001	-1.0377	0.2994
CC	0.4492	0.0718	6.2541	0.0000
RF	0.4713	0.0632	7.4526	0.0000
GB1:RF	0.0709	0.1155	0.6137	0.5394
GC1:RF	-0.3311	0.2861	-1.1574	0.2471
CC1:RF	-0.9385	0.2991	-3.1381	0.0017

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares: 2.1317
Residual Sum of Squares: 0.25181
R-Squared: 0.88188
Adj. R-Squared: 0.87877
Chisq: 3120.63 on 11 DF, p-value: < 2.22e-16

***FS** : Financial Sustainability ; **FIRMSIZE**: Firm Size, **FIRMAGE**: Firm Age, **CC**: Carbon Credit, **RF**: Regulatory Framework*

***Source:** Research Data (2026)*

Importantly, the interaction between carbon credits and regulatory framework (CC × RF) was negative and statistically significant (β = −0.9385, z = −3.1381, p = 0.0017). This indicates that regulatory framework significantly moderates the relationship between carbon credits and financial sustainability, with the negative interaction suggesting that an increase in regulatory framework weakens the positive relationship between carbon credits and financial sustainability. The other interaction terms, GB1 × RF (β = 0.0709, p = 0.5394) and GC1 × RF (β = −0.3311, p = 0.2471), were statistically insignificant.

Based on the statistically significant negative interaction coefficient, the null hypothesis (H_{02}), which stated that regulatory framework does not significantly moderate the relationship between carbon credits and financial sustainability was rejected. The findings demonstrate that the relationship between carbon credits and financial sustainability is significantly conditioned by the regulatory framework. The moderation graph (Figure 1) corroborates this pattern financial sustainability increases with carbon credits at low, medium and high levels of the regulatory framework, but the slope is visibly flatter at higher regulatory levels.

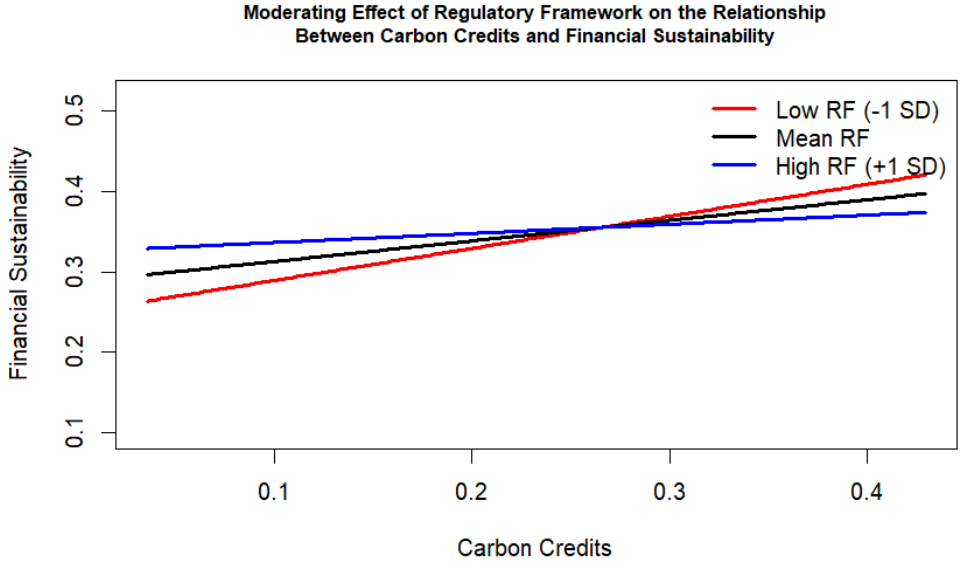


Figure 1: Modgraph Carbon Credits, Regulatory Framework and Financial Sustainability

Accordingly, the null hypothesis H_{02} which stated that regulatory framework has no moderating effect on the relationship between carbon credits and financial sustainability was rejected. Regulatory framework significantly and negatively moderates the carbon credits–financial sustainability relationship.

Discussion

The findings indicate that carbon credits have a positive and statistically significant effect on the financial sustainability of firms listed on the NSE ($\beta = 0.2663$, $p < 0.001$). This is further supported by the strong positive correlation between carbon credits and financial sustainability ($r = 0.714$, $p < 0.001$). The results suggest that participation in carbon credit mechanisms is associated with improved financial sustainability, potentially through additional revenue opportunities from verified emission reductions and enhanced environmental credibility. This finding is consistent with Martielli et al. (2025), who reported a positive relationship between carbon credit mechanisms and the financial performance of listed firms, and Hou et al. (2025), who established significant associations between emission-related performance and financial indicators among South African firms. Similarly, Martielli (2024) concluded that carbon offsets and credits can mitigate the adverse financial implications of carbon emissions. However, the finding differs from Park et al. (2024), who reported that emissions trading reduced the long-term value of listed firms. The difference may reflect variations in regulatory environments, carbon market maturity and the costs associated with participation in emissions trading schemes.

The study also established that regulatory framework significantly and negatively moderates the relationship between carbon credits and financial sustainability ($\beta = -0.9385$, $p = 0.0017$). This suggests that stronger regulatory frameworks weaken the positive relationship between carbon credit participation and financial sustainability. From an institutional theory perspective, increased regulatory requirements may expose firms to additional compliance, monitoring, reporting and verification costs, potentially reducing the financial benefits associated with carbon credit

activities (Nian et al., 2025; Schmuck et al., 2025). This finding is consistent with Wendy (2026), who reported that regulatory stringency may weaken the relationship between environmental performance and profitability where implementation and enforcement remain challenging. However, it contrasts with Liu et al. (2025), who found that environmental regulation strengthened the financial benefits of carbon information disclosure among Chinese listed firms, and Bhardwaj et al. (2025), who identified positive complementarities between carbon credit activities and financial performance under supportive regulatory conditions. These differences suggest that the financial implications of regulation may depend on regulatory design, implementation and compliance requirements.

Conclusion and Recommendations

Conclusion

The study examined the effect of carbon credits on the financial sustainability of firms listed on the Nairobi Securities Exchange (NSE), Kenya, and the moderating effect of the regulatory framework. Carbon credits had a positive and statistically significant effect on financial sustainability: firms that reduced emission intensity, traded or retired credits, and invested in audited offset projects recorded stronger performance, confirming that carbon credits are a financially value-creating instrument and not merely an environmental one.

The regulatory framework, while exerting a positive direct effect on financial sustainability, significantly and negatively moderated this relationship: as regulatory requirements intensify, the marginal financial benefit of carbon credit participation diminishes, plausibly because monitoring, reporting, verification and compliance costs absorb part of the gains. With the final model explaining 88.19% of the variation in financial sustainability, the findings confirm that the financial payoff of carbon credits is contingent on the design and stringency of the regulatory environment in which firms operate.

Recommendations for Policy

Policymakers, particularly the Capital Markets Authority (CMA), the National Environment Management Authority (NEMA) and the National Treasury, should streamline monitoring, reporting and verification procedures under the Climate Change (Carbon Markets) Regulations, 2024 so that environmental integrity is protected without imposing disproportionate participation costs; adopt graduated compliance requirements calibrated to firm size and carbon-market maturity; strengthen carbon-related disclosure standards and benefit-sharing clarity; and introduce fiscal incentives such as tax credits or fee relief for verified carbon credit projects to preserve the financial attractiveness of carbon markets in Kenya.

Recommendations for Practice

Managers of NSE-listed firms should treat carbon credit activities as a source of financial value rather than symbolic compliance: integrate carbon credit strategies into core operations, invest in credible and verifiable offset projects, build capacity to manage regulatory compliance cost-effectively, and budget for verification and reporting obligations within carbon project appraisals. For investors and analysts, carbon credit intensity emerges as a meaningful indicator of financial sustainability, though its payoff should be

evaluated against each firm's regulatory exposure and compliance efficiency.

Limitations of the Study

The study relies on secondary data from audited reports and regulatory disclosures, so the findings depend on firms' reporting practices and accuracy. The composite regulatory index (EPR compliance and the CMA Code) may not capture the full breadth of environmental regulations affecting the firms; the moderating effect was estimated contemporaneously, overlooking potential time lags; the sample of 43 NSE-listed firms limits generalizability to unlisted companies, smaller enterprises and broader African markets; and results were not disaggregated by sector despite varying carbon-market exposure across industries.

Suggestions for Future Research

Future studies should extend the analysis to unlisted firms and small and medium-sized enterprises; examine alternative measures of the regulatory framework, such as enforcement intensity, carbon pricing stringency or disclosure mandates; undertake cross-country comparisons across African securities exchanges; and employ dynamic panel estimators with lagged interaction structures and sector disaggregation to capture the time-dependent and industry-specific dimensions of the carbon credits–financial sustainability relationship.

References

Adamolekun, G., Li, H., & Xu, B. (2025). Carbon markets and firms' perceived climate regulatory risk. *Journal of Environmental Management*, 393, Article 127050. https://doi.org/10.1016/j.jenvman.2025.127050

Ahlström, H., & Monciardini, D. (2022). The regulatory dynamics of sustainable finance: Paradoxical success and limitations of EU reforms. *Journal of Business Ethics*, 177(1), 193–212. https://doi.org/10.1007/s10551-021-04763-x

Aibar-Guzmán, B., Raimo, N., Vitolla, F., & García-Sánchez, I.-M. (2024). Corporate governance and financial performance: Reframing their relationship in the context of climate change. *Corporate Social Responsibility and Environmental Management*, 31(3), 1493–1509. https://doi.org/10.1002/csr.2649

Alanoca, S., Gur-Arieh, S., Zick, T., & Klyman, K. (2025). Comparing apples to oranges: A taxonomy for navigating the global landscape of AI regulation. In *Proceedings of the 2025 ACM Conference on Fairness, Accountability, and Transparency*. ACM. https://doi.org/10.1145/3715275.3732059

Bhardwaj, M., Prakash, N., Malhotra, R. K., & Johri, A. (2025). Investigating the influence of carbon credit accounting practices on corporate financial performance in the Himalayan region. *Discover Sustainability*, 6(1), Article 1265. https://doi.org/10.1007/s43621-025-01478-1

Blair, G., Coppock, A., & Humphreys, M. (2023). *Research design in the social sciences: Declaration, diagnosis, and redesign*. Princeton University Press. https://doi.org/10.1515/9780691199580

Choube, M., Oh, J., & Zünd, S. (2024). *Scope 3 emissions accounting and reporting for the United Nations system*. United Nations.

Datt, R., Luo, L., & Segara, R. (2025). Voluntary carbon assurance and the cost of equity capital: International evidence. *Australian Journal of Management*, 50(4), 1129–1165. https://doi.org/10.1177/03128962241251498

Delacote, P., Creti, A., & L'Horty, T. (2025). Restoring trust in carbon credits for climate action. *PLOS Climate*, 4(11), Article e0000760.

https://doi.org/10.1371/journal.pclm.0000760

Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business*. Capstone. https://doi.org/10.1002/tqem.3310080106

Emenekwe, C. C., Onyeneke, R. U., & Nwajiuba, C. U. (2022). Financial development and carbon emissions in Sub-Saharan Africa. *Environmental Science and Pollution Research*, 29(13), 19624–19641. https://doi.org/10.1007/s11356-021-17161-7

Gao, J. (2024). R-Squared (R^2)-How much variation is explained? *Research Methods in Medicine & Health Sciences*, 5(4), 104–109. https://doi.org/10.1177/26320843231186398

Gautam, S., Gautam, A. S., Awasthi, A., & N, R. (2024). Regulatory frameworks and policies. In *Sustainable air: Strategies for cleaner atmosphere and healthier communities* (pp. 49–52). Springer. https://doi.org/10.1007/978-3-031-77057-9_7

Githaiga, P. N. (2026). Corporate sustainability disclosure and investment efficiency: An empirical analysis of East Africa Community listed firms. *Asian Journal of Accounting Research*, 11(3), 270–286. https://doi.org/10.1108/AJAR-12-2023-0437

Gleißner, W., Günther, T., & Walkshäusl, C. (2022). Financial sustainability: Measurement and empirical evidence. *Journal of Business Economics*, 92(3), 467–516. https://doi.org/10.1007/s11573-022-01081-0

Government of Kenya. (2016). *Climate Change Act, No. 11 of 2016*. Government Printer.

Government of Kenya. (2023). *Climate Change (Amendment) Act, 2023*. Government Printer.

Government of Kenya. (2024). *Climate Change (Carbon Markets) Regulations, 2024* (Kenya Gazette Supplement). Government Printer.

Hou, T. C.-T., Tran, N. H., Msefula, G., & Dlamini, N. N. (2025). Corporate carbon emissions and firm performance in South Africa. *Review of Integrative Business and Economics Research*, 14(1), 55–71.

Hu, X., & Xu, H. (2023). Design and implementation of project schedule management data collection and analysis system. *Journal of Physics: Conference Series*, 2425, Article 012062. https://doi.org/10.1088/1742-6596/2425/1/012062

Ibrahim, A. G. (2024). *Internal corporate governance mechanism and firms value of selected companies listed at the Nairobi Securities Exchange, Kenya* [Unpublished master's thesis or doctoral dissertation]. https://doi.org/10.9790/5933-1505051020

Jeriji, M., & Nasfi, A. (2023). The value relevance of mandatory sustainability reporting assurance. *South African Journal of Accounting Research*, 37(2), 122–138. https://doi.org/10.1080/10291954.2022.2148887

Karadayi, N. (2023). Determinants of return on assets. *European Journal of Business and Management Research*, 8(3), 37–44. https://doi.org/10.24018/ejbmr.2023.8.3.1938

Li, D., Li, T., Yi, K., & Liu, Y. (2022). Size effect and the measurement of firm size. *Managerial and Decision Economics*, 43(4), 894–905. https://doi.org/10.1002/mde.3425

Liu, R., Che Abdul Rahman, M. R., & Jamil, A. H. (2025). Leveraging environmental regulation: How green innovation moderates the relationship between carbon information disclosure and firm value. *Sustainability*, 17(6), Article 2597. https://doi.org/10.3390/su17062597

Lortz, S. A., Setiono, A., Kovacs, M., & van Ravenzwaaij, D. (2026). Sample-size planning for frequentist and Bayesian 2×2 analysis-of-variance

designs. *Advances in Methods and Practices in Psychological Science*, 9(1). https://doi.org/10.1177/25152459251398805

Martielli, F. (2024). *Financial solutions in response to climate change: How carbon credits can improve financial performance* [Systematic literature review].

Martielli, F., Battisti, E., Gonzalez-Cruz, T. F., & Salvi, A. (2025). Carbon credits and financial performance: Exploring the moderating role of CSR strategy and corporate governance practices. *Research in International Business and Finance*, 77, Article 102919. https://doi.org/10.1016/j.ribaf.2025.102919

Mishra, B., & Kumar, A. (2023). How does regulatory framework impact sectoral performance? A systematic literature review. *International Journal of Productivity and Performance Management*, 72(5), 1419–1444. https://doi.org/10.1108/IJPPM-07-2021-0398

Mweta, T. M. (2024). *Corporate governance mechanisms, regulatory framework and financial performance of publicly cross-listed companies at East African Community region* (Doctoral dissertation, Kenyatta University).

Nairobi Securities Exchange. (2021). *ESG disclosures guidance manual*. https://www.nse.co.ke/wp-content/uploads/NSE-ESG-Disclosures-Guidance-Manual.pdf

National Environment Management Authority. (2024). *Sustainable Waste Management (Extended Producer Responsibility) Regulations, 2024* (Legal Notice No. 176, Kenya Gazette Supplement No. 196). https://nema.go.ke/wp-content/uploads/2025/07/EPR-AND-WATER-QUALITY-REGULATIONS-2024.pdf

Nawaz, F., Kayani, U., ElRefae, G. A., Hasan, F., & Bazai, H. S. K. (2025). Economic growth and carbon emissions nexus: Environmental sustainability-A case of Japan from East Asia. *Discover Sustainability*, 6(1), Article 177. https://doi.org/10.1007/s43621-025-00941-3

Nian, H., Wang, H., & Zhang, Z. (2025). Carbon credit and credibility in lawsuit: Evidence from CCER firms in China. *Energy Economics*, 146, Article 108480. https://doi.org/10.1016/j.eneco.2025.108480

Okillong, P., & Luwedde, J. (2023). The effects of industrialization and financial development on carbon emissions in Uganda. *African Studies: Effects of Environmental Factors on Economic Development*, 55.

Omukuti, J., Njoroge, H., Valenzuela, J. M., Lezaun, J., & Olalere, Y. (2024). *Making carbon markets work for Africa: A 7-point plan*. Oxford Net Zero, Strathmore University & INSIS. https://netzeroclimate.org/publications/making-carbon-markets-work-for-africa-a-7-point-plan/

Park, H., Khue, P. M., & Lee, J. (2024). The effects of carbon emissions trading on profitability and value: Evidence from Korean listed firms. *Journal of International Financial Management & Accounting*, 35(3), 760–799. https://doi.org/10.1111/jifm.12211

Park, S.-J., & Yi, Y. (2022). Assessing moderator effects, main effects, and simple effects without collinearity problems in moderated regression models. *Journal of Business Research*, 145, 905–919. https://doi.org/10.1016/j.jbusres.2022.03.018

Park, Y. S., Konge, L., & Artino, A. R., Jr. (2020). The positivism paradigm of research. *Academic Medicine*, 95(5), 690–694. https://doi.org/10.1097/ACM.0000000000003093

Probst, B. S., Toetzke, M., Kontoleon, A., Díaz Anadón, L., Minx, J. C., Haya, B. K., Schneider, L., Trotter, P. A., West, T. A. P., Gill-Wiehl, A., & Hoffmann, V. H. (2024). Systematic assessment of the achieved emission reductions of carbon crediting projects. *Nature Communications*, 15, Article 9562.

https://doi.org/10.1038/s41467-024-53645-z

Rimpler, A., Kiers, H. A., & van Ravenzwaaij, D. (2025). To interact or not to interact: The pros and cons of including interactions in linear regression models. *Behavior Research Methods*, 57(3), Article 92. https://doi.org/10.3758/s13428-025-02613-6

Salvi, A., Martielli, F., Battisti, E., Forliano, C., & Kumar, S. (2025). Climate change management and companies' financial performance: Exploring the moderating role of carbon credits. *Research in International Business and Finance*, 75, Article 102785. https://doi.org/10.1016/j.ribaf.2025.102785

Schmuck, D., Andersson, H., & Mark-Herbert, C. (2025). Corporate motives for financing carbon offsets: A case study of Swedish corporations. *Journal of Cleaner Production*, 520, Article 146049. https://doi.org/10.1016/j.jclepro.2025.146049

Setyowati, A. B. (2023). Governing sustainable finance: Insights from Indonesia. *Climate Policy*, 23(1), 108–121. https://doi.org/10.1080/14693062.2020.1858741

Sidharth, G. (2023). Research designs for contemporary social science research: An overview. *International Research Journal of Management, Sociology & Humanities*, 14(1), 381–392.

Stek, P. E., Lima-de-Oliveira, R., & Vasudhevan, T. (2025). The development of carbon markets in upper-middle-income countries. *Regulation & Governance*, 19(2), 482–495. https://doi.org/10.1111/rego.70010

Trouwloon, D., Streck, C., Chagas, T., & Martinus, G. (2023). Understanding the use of carbon credits by companies: A review of the defining elements of corporate climate claims. *Global Challenges*, 7(4), Article 2200158. https://doi.org/10.1002/gch2.202200158

Tumu, K., Vorst, K., & Curtzwiler, G. (2023). Global plastic waste recycling and extended producer responsibility laws. *Journal of Environmental Management*, 348, Article 119242. https://doi.org/10.1016/j.jenvman.2023.119242

United Nations University Institute for Natural Resources in Africa. (2024). *Carbon market economies: Crafting a new narrative of opportunity and sustainable growth for climate action in Africa*. UNU-INRA. https://unu.edu/publication/carbon-market-economies-crafting-new-narrative-opportunity-and-sustainable-growth

Wang, G., Feng, X., Tian, L. G., & Tu, Y. (2024). Environmental regulation, green technology innovation and enterprise performance. *Finance Research Letters*, 68, Article 105983. https://doi.org/10.1016/j.frl.2024.105983

Wendy, A. F. (2026). Relationship between carbon emissions and financial performance: Fixed-effects panel model focused on sectoral and regulatory heterogeneity. *Quality & Quantity*, 60(5). https://doi.org/10.1007/s11135-026-02793-z

Wetterberg, K., Ellis, J., & Schneider, L. (2024). *The interplay between voluntary and compliance carbon markets: Implications for environmental integrity* (OECD Environment Working Papers No. 244). OECD Publishing. https://doi.org/10.1787/500198e1-en

Wetterberg, K., Lanzi, E., & Gómez, N. (2025). *Exploring governments' efforts to shape carbon credit markets* (OECD Environment Working Papers). OECD Publishing. https://doi.org/10.1787/0bafe9af-en

Xu, X., Wang, S., Li, J., & Qiao, T. (2024). Environmental regulatory intensity, green finance and corporate green

sustainable development performance. *Heliyon*, 10(9), Article e30114. https://doi.org/10.1016/j.heliyon.2024.e30114

Yi, C., & Latiff, A. R. B. A. (2024). The role of regulatory frameworks in shaping the firm value of cross-listed companies: A comparative analysis. *Journal of Digitainability, Realism & Mastery (DREAM)*, 3(04), 10–25. https://doi.org/10.56982/dream.v3i04.225

Yong, W. K., Husin, M. M., & Kamarudin, S. (2021). Understanding research paradigms: A scientific guide. *Journal of Contemporary Issues in Business and Government*, 27(2).

Zheng, Z. (2024). Study on the impact of green credit on carbon emission reduction in the manufacturing industry. *Interdisciplinary Humanities and Communication Studies*, 1(9). https://doi.org/10.61173/eqsykj06