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Carbon Credit Accounting and Climate Change Mitigation of Oil and Gas Firms in Nigeria

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ABSTRACT: The study examined the effect of carbon credit accounting on climate change mitigation among oil and gas firms in Nigeria. Specifically, it assessed the effects of emission intensity ratio (EIR), carbon cost intensity ratio (CCIR), renewables and energy mix (REM), environmental liability ratio (ELR), energy intensity ratio (ENIR), and gas flaring ratio (GFR) on emissions reduction rate (ERR) among listed oil and gas firms in Nigeria. An ex-post facto research design was adopted, using historical environmental and financial data obtained from firms' annual reports, sustainability reports, and audited financial statements. A longitudinal panel framework was employed to account for firm-level and time-based variations in carbon credit accounting practices and emissions reduction performance. The population comprised all 8 oil and gas firms listed on the Nigerian Exchange Group as of 31 May 2026, and a census sampling technique was adopted due to the manageable population size. The study covered a 10-year period from 2016 to 2025. Data analysis was conducted using E-Views Version 9.0, employing descriptive statistics, correlation analysis, cross-sectional dependence tests, panel unit root tests, Pedroni cointegration tests, redundant fixed effects tests, Hausman tests, and panel regression estimation. The findings showed that EIR had a positive and significant effect on ERR, with a coefficient of 0.158532 and probability value of 0.0002, resulting in the rejection of the null hypothesis. CCIR also exerted a positive and significant effect on ERR, with a coefficient of 0.123955 and probability value of 0.0000. REM had a positive and significant effect, with a coefficient of 0.124114 and probability value of 0.0000. Conversely, ELR had a negative but significant effect on ERR, with a coefficient of -0.150372 and probability value of 0.0474. ENIR and GFR had negative but insignificant effects, with probability values of 0.2380 and 0.7239, respectively. The study concluded that carbon credit accounting practices significantly contributed to climate change mitigation and recommended stronger carbon accounting, emission monitoring, carbon cost integration, renewable energy investment, environmental liability management, energy efficiency, and gas flaring reduction initiatives.

KEYWORDS: Emissions reduction rate, Emission intensity ratio, Carbon cost intensity ratio, Renewable energy and energy mix, Environmental liability ratio, Energy intensity ratio and Gas flaring ratio

INTRODUCTION

Climate change has emerged as a major global environmental challenge due to increasing greenhouse gas emissions associated with industrialization, fossil fuel consumption, and unsustainable production activities. Its effects include rising temperatures, flooding, drought, desertification, and ecosystem destruction. Adebayo and Ologun (2024) noted that growing environmental threats have intensified demands for sustainable practices and effective carbon emission control, while Yusuf and Ahmed (2023) observed that carbon-intensive industries face increasing pressure to reduce their environmental footprint. Carbon credit accounting has therefore become an important environmental management mechanism involving the measurement, recording, monitoring, and reporting of carbon emissions, carbon credits, and costs. It enables firms to assess environmental impacts, monitor emissions reduction targets, and communicate climate-related performance to stakeholders. Egbunike and Okafor (2024) emphasized that carbon credit accounting promotes transparency, accountability, and corporate commitment to climate change mitigation.

The oil and gas industry remains a significant contributor to environmental pollution and carbon emissions through crude oil exploration, refining, transportation, and gas flaring. In Nigeria, despite its contribution to economic development and government revenue, the sector has also caused environmental degradation and ecological imbalance. Oil-producing communities experience water pollution, farmland destruction, and health challenges from oil spills and gas emissions. Ezeani and Nwankwo (2025) observed that pollution from oil and gas operations has increased concerns about environmental accountability and sustainable resource management, while Ibrahim and Sani (2024) stressed the need for improved environmental reporting and carbon management. Emission intensity ratio (EIR) measures greenhouse gas emissions relative to operational output and indicates environmental efficiency. Chukwu and Adeyemi (2023) argued that reducing emission intensity is essential for improving environmental sustainability. Hassan and Musa (2024) linked EIR with better performance.

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Carbon cost intensity ratio (CCIR) reflects carbon-related expenses incurred through pollution control, environmental compliance, carbon taxes, and remediation activities. Adekunle and Eze (2025) associated carbon cost management with sustainability. Renewables and energy mix (REM) matters because the transition from fossil fuels to renewable sources such as solar and wind can reduce emissions and promote cleaner production. Okoye and Nnamdi (2024) explained that renewable energy investment supports environmental sustainability, while Salisu and Mohammed (2023) argued that renewable energy adoption helps organizations reduce greenhouse gas emissions and strengthen climate change mitigation. Environmental liability ratio (ELR) measures obligations arising from pollution, oil spills, gas emissions, clean-up costs, and compensation claims. Nwachukwu and Obi (2025) highlighted liability risks. Transparent disclosure and effective management of such obligations are therefore essential for strengthening environmental accountability and reducing potential financial and reputational consequences.

Energy intensity ratio (ENIR) measures energy consumption relative to production output and indicates operational efficiency. High energy intensity may suggest inefficient energy use and excessive carbon emissions. Olatunji and Ibrahim (2023) stated that improved energy efficiency contributes to reducing greenhouse gas emissions and promoting sustainable industrial operations. Emeh and Afolabi (2025) further explained that energy-efficient production systems help organizations minimize operational costs and improve environmental performance. Gas flaring ratio (GFR) remains a critical environmental concern in Nigeria because gas flaring releases carbon dioxide and methane. Despite regulatory interventions, persistent flaring contributes to air pollution, acid rain, climate change, and public health challenges. Usman and Idris (2024) observed that continued gas flaring undermines environmental sustainability and climate protection. Reducing gas flaring is therefore important for improving climate change mitigation within the Nigerian oil and gas industry.

Climate change mitigation involves strategies to reduce greenhouse gas emissions and minimize environmental degradation through sustainable operations and environmental management systems. Emissions reduction rate (ERR) measures the extent to which organizations reduce emissions. Previous studies have examined environmental disclosure, renewable energy, environmental liabilities, gas flaring, and carbon emissions from different perspectives, but evidence remains fragmented. Existing research has also relied on cross-sectional or ordinary least squares approaches that inadequately capture differences across firms and periods. Consequently, a panel approach provides a suitable framework for examining firm-level and time-based variations. The study is expected to provide integrated empirical evidence on how carbon credit accounting practices influence climate change mitigation and support sustainable environmental management in the sector. Specifically, this study therefore focuses on the effects of EIR, CCIR, REM, ELR, ENIR, and GFR on ERR among oil and gas firms in Nigeria.

The following research hypotheses were formulated for the study:

Ho_1: Emission Intensity Ratio has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.
Ho_2: Carbon Cost Intensity Ratio has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.
Ho_3: Renewables and Energy Mix has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.
Ho_4: Environmental Liability Ratio has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.
Ho_5: Energy Intensity Ratio has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.
Ho_6: Gas Flaring Ratio has no significant effect on Emissions Reduction Rate of oil and gas firms in Nigeria.

LITERATURE REVIEW

Conceptual Review

Carbon Credit Accounting

Carbon credit accounting has become an important component of environmental sustainability and corporate environmental management due to increasing global concern about climate change and greenhouse gas emissions. It involves the identification, measurement, recording, monitoring, and reporting of carbon emissions and environmental costs associated with organizational activities. The concept developed from international environmental agreements and sustainability frameworks designed to reduce carbon emissions and promote environmental accountability. Nwafor and Okeke (2023) explained that carbon credit accounting provides organizations with a structured approach for monitoring emissions and evaluating environmental sustainability performance. Similarly, Adeyemi and Yusuf (2024) noted that growing demands for environmental transparency have increased the relevance of carbon accounting practices across environmentally sensitive industries. Carbon accounting enables firms to quantify their environmental impacts, assess emissions reduction strategies, improve environmental disclosure, and integrate environmental considerations into operational and financial decision-making.

Carbon credit accounting also supports climate change mitigation and environmental protection by helping firms identify major sources of greenhouse gas emissions and implement appropriate reduction strategies. Eze and Ibrahim (2022) noted that carbon accounting systems enable organizations to evaluate the environmental effects of their activities and assess the effectiveness of emissions reduction measures. Onwuka and Bello (2024) further explained that effective carbon accounting encourages the adoption of cleaner technologies, renewable energy systems, and energy-efficient production processes. Carbon accounting is also associated with carbon trading systems and international environmental frameworks such as the Kyoto Protocol and Paris Agreement, enabling firms to determine carbon liabilities, measure emissions reduction performance, and participate in carbon market opportunities (Nwachukwu and Obi 2025). Environmental cost management is another important dimension, as firms incur costs relating to emissions monitoring, pollution control, gas flaring reduction, environmental remediation, and sustainability reporting. Despite challenges such as inadequate disclosure, inconsistent emissions measurement, weak regulatory enforcement, and limited technological infrastructure, carbon credit accounting remains essential for strengthening environmental accountability, supporting emissions reduction, and promoting sustainable industrial development.

Climate Change Mitigation, measured with Emissions Reduction Rate (ERR)

Climate change mitigation refers to the strategies, policies, and operational measures adopted to reduce greenhouse gas emissions and minimize the adverse environmental consequences associated with climate change. It focuses on controlling carbon emissions through sustainable environmental management, cleaner energy utilization, improved resource efficiency, and environmentally responsible production practices. The

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growing concern over global warming, biodiversity loss, flooding, desertification, and extreme weather events has increased the importance of mitigation initiatives among governments and organizations. Adegbite and Nwosu (2023) explained that climate change mitigation provides a framework for reducing environmental pollution and promoting sustainable economic development, while Yusuf and Ezeani (2024) emphasized that mitigation involves both preventive and corrective actions aimed at reducing carbon emissions and improving ecological sustainability. Within the oil and gas industry, climate change mitigation is particularly important due to emissions generated from exploration, refining, transportation, and gas flaring activities. Effective mitigation practices involve reducing gas flaring, improving energy efficiency, adopting renewable energy systems, and strengthening environmental management systems.

Emissions Reduction Rate (ERR) serves as a measurable indicator for assessing the effectiveness of climate change mitigation efforts. It represents the percentage decrease in greenhouse gas emissions achieved by organizations over a specific period and reflects the success of emissions management strategies, cleaner technologies, renewable energy adoption, and operational improvements. Adebayo and Nnamdi (2023) noted that ERR provides a measurable framework for evaluating organizational commitment toward environmental sustainability and climate change mitigation. Similarly, Ibrahim and Ezeh (2024) explained that higher emissions reduction rates indicate improved environmental efficiency and stronger sustainability performance. In carbon-intensive industries such as oil and gas, ERR provides an important basis for evaluating firms' ability to reduce emissions and improve environmental performance. Therefore, climate change mitigation measured through ERR captures the extent to which organizations implement effective environmental practices capable of reducing greenhouse gas emissions and supporting long-term sustainability objectives.

THEORETICAL REVIEW

The study was anchored jointly on legitimacy theory and stakeholder theory to explain how carbon credit accounting practices influence climate change mitigation through environmental accountability, stakeholder pressure, sustainability reporting, and emissions reduction performance among oil and gas firms in Nigeria.

Legitimacy Theory, developed by Dowling and Pfeffer (1975), explains that organizations operate within a social contract and must align their activities with societal values and expectations to maintain acceptance. The theory suggests that firms adopt responsible environmental practices to protect their legitimacy, especially when their operations create environmental concerns. In the context of carbon credit accounting, the theory explains why oil and gas firms measure, disclose, and manage carbon-related activities to demonstrate environmental responsibility. Practices such as emissions monitoring, carbon cost management, renewable energy adoption, and gas flaring reduction help firms improve environmental performance and strengthen stakeholder confidence. According to Obiora and Garuba (2024), sustainability disclosures enhance organizational legitimacy by demonstrating commitment to environmental accountability and climate change mitigation. Therefore, Legitimacy Theory provides a suitable basis for explaining the relationship between carbon credit accounting and emissions reduction performance.

Stakeholder Theory, developed by R. Edward Freeman (1984), explains that organizations are accountable not only to shareholders but also to stakeholders affected by their activities, including investors, governments, employees, host communities, and society. The theory emphasizes that long-term organizational success depends on balancing stakeholder interests and responding to their expectations. In relation to carbon credit accounting, the theory explains why oil and gas firms measure, disclose, and manage carbon-related information to demonstrate environmental responsibility. Carbon accounting practices provide stakeholders with evidence of firms' efforts in emissions management, renewable energy adoption, environmental liability control, and sustainability performance. Recent studies indicate that transparent environmental information disclosure improves corporate environmental performance and strengthens stakeholder confidence in sustainability practices (Eze and Olatunji, 2025). Therefore, Stakeholder Theory provides a foundation for understanding how stakeholder pressure influences carbon credit accounting practices and climate change mitigation efforts among oil and gas firms.

EMPIRICAL REVIEW

Suleiman et al. (2026) examined the effect of environmental accounting disclosure on the financial performance of listed oil and gas companies in Nigeria. The study covered 2015–2024 and adopted a survey research design and panel data methodology. Using annual reports, sustainability reports, questionnaires, and documentary analysis, regression analysis was conducted. Findings showed that environmental accounting disclosure positively influenced performance and sustainability. The study recommended mandatory environmental disclosure standards. Etim et al. (2025) investigated the effect of green accounting on the financial performance of Nigerian oil and gas companies. The study covered 2014–2023 using secondary data from annual reports of listed firms. An ex-post facto research design and panel regression analysis were employed. Findings revealed that green accounting significantly improved environmental accountability and organizational performance. The study concluded that green accounting supports sustainable growth and recommended stronger sustainability reporting compliance.

Ademola and Salawu (2025) examined the effect of green accounting disclosure on the performance of listed oil and gas companies in Nigeria. Using annual report data covering 2013–2021, the study adopted panel regression and generalized linear models. Green accounting disclosure served as the explanatory variable, while firm performance indicators were dependent variables. Findings revealed a significant positive relationship, leading to the recommendation of improved environmental disclosure compliance. Tonye and Boubai (2025) examined ESG reporting disclosures and financial performance of Nigerian oil and gas companies. The study covered 2019–2023 and involved 8 listed companies. Using annual report data, correlation and regression analyses were applied to assess ESG disclosures and ROE. Findings indicated that ESG reporting improved financial performance. The study concluded that sustainability reporting creates corporate value and recommended integrated ESG reporting frameworks.

Eze et al. (2024) examined climate accounting and sustainability reporting among Nigerian oil firms using data covering 2013–2023 from annual reports. The study adopted an ex-post facto design and panel regression techniques. Variables included climate accounting disclosure, ELR, and ERR. Findings showed that climate accounting significantly improved sustainability reporting and ERR. The study recommended mandatory climate disclosure standards. Bello and Yusuf (2024) investigated gas flaring management and climate change mitigation in Nigeria. The study

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examined the relationship between GFR and ERR using NUPRC data covering 2010–2023. Regression analysis was employed. Findings revealed that reduced gas flaring significantly improved emission reduction outcomes. The study concluded that flare control is essential for climate mitigation and recommended stricter anti-flaring enforcement.

Onoh and Ezeani (2024) evaluated carbon cost intensity and environmental sustainability among listed oil firms. Using annual report data covering 2012–2023, the study examined CCIR and sustainability performance through panel least squares regression. Findings indicated that carbon cost management positively influenced sustainability performance. The study concluded that effective carbon cost accounting improves environmental responsibility and recommended comprehensive carbon pricing frameworks. Garcia and Martinez (2023) examined emission intensity management and sustainability outcomes among European oil firms. The study analyzed emission intensity ratio (EIR) and sustainability performance indicators using panel data covering 2010–2022. Fixed-effect regression was employed for analysis. Findings revealed that lower EIR significantly improved sustainability outcomes. The study concluded that effective emission intensity management enhances environmental performance and recommended continuous monitoring systems for improved emissions control and sustainability reporting.

Singh and Patel (2023) investigated environmental liabilities and climate performance among Asian energy firms. Environmental liability ratio (ELR) and climate mitigation indicators were examined using annual report data covering 2011–2022. Panel regression was employed to assess the relationship between the variables. Findings showed that greater recognition of environmental liabilities improved climate performance. The study concluded that environmental liability accounting strengthens sustainability commitments and recommended enhanced environmental liability disclosure policies. Johnson and Wang (2023) examined carbon accounting systems and emission reduction among international oil companies. The study analyzed carbon accounting disclosure and emission reduction rate (ERR) using global energy datasets covering 2010–2022. Panel regression analysis was employed. Findings indicated that effective carbon accounting significantly improved emission reduction performance. The study concluded that carbon accounting promotes climate accountability and recommended harmonized international carbon reporting standards to enhance transparency and emission management.

Adewale and Adebisi (2023) investigated renewable energy transition and carbon reduction among oil firms. Renewable energy mix (REM) and emission reduction rate (ERR) were examined using panel data covering 2011–2022. Regression analysis was employed to determine the effect of renewable energy adoption on emission reduction. Findings revealed a significant positive effect of renewable energy adoption on emission reduction. The study concluded that energy transition supports climate mitigation and recommended increased investment in clean energy technologies. Usman and Suleiman (2023) examined greenhouse gas accounting and environmental sustainability among Sub-Saharan African oil firms. The study assessed emission intensity ratio (EIR) and sustainability indicators using sustainability report data covering 2010–2022. Panel regression analysis was employed to examine the relationship between greenhouse gas accounting and sustainability outcomes. Findings revealed that effective greenhouse gas accounting significantly reduced emission intensity. The study concluded that emission accounting promotes environmental sustainability and recommended stronger greenhouse gas reporting frameworks.

Akintoye and Oladimeji (2023) investigated carbon cost accounting and corporate environmental responsibility among firms. The study used carbon cost intensity ratio (CCIR) as the independent variable and environmental responsibility performance as the dependent variable, using annual report data covering 2011–2022. Fixed-effect regression was employed for analysis. Findings indicated that effective carbon cost management improved environmental responsibility. The study concluded that CCIR supports sustainability decisions and recommended integrating carbon costs into corporate planning. Okolie et al. (2022) examined the impact of sustainability accounting on the performance of manufacturing firms in Nigeria. The study adopted an ex-post facto research design using 6-year time-series data from annual reports of selected manufacturing firms. Data were analyzed using E-Views Version 9. Findings showed that social and environmental costs significantly improved firm performance, while corporate governance had no positive effect. The study concluded that sustainability accounting enhances performance and recommended improved environmental cost reporting and disclosure practices.

RESEARCH METHODOLOGY

This study adopted an ex-post facto research design because it utilized historical environmental and financial data obtained from selected oil and gas firms without manipulation by the researcher. The design was considered appropriate for examining the effect of carbon credit accounting on climate change mitigation among listed oil and gas firms in Nigeria. A longitudinal panel framework was employed to capture both cross-sectional and time-series variations in carbon credit accounting practices and emissions reduction performance. The population comprised all 8 oil and gas firms listed on the Nigerian Exchange Group (NGX) as of 31st May 2026. A census sampling technique was adopted, making the entire population the sample size due to its manageable size and ensuring comprehensive representation of the sector. Secondary data were collected from annual reports, sustainability reports, and audited financial statements covering the period 2016–2025.

Data analysis was conducted using E-Views Version 9.0 through descriptive and inferential statistical techniques. The study employed panel least squares estimation and conducted preliminary diagnostic tests, including descriptive statistics, correlation analysis, cross-sectional dependence tests, panel unit root tests, Pedroni panel cointegration tests, redundant fixed effects tests, and Hausman tests. Descriptive statistics examined the characteristics of the variables, while correlation analysis assessed relationships and possible multicollinearity among EIR, CCIR, REM, ELR, ENIR, GFR, and ERR. Cross-sectional dependence and panel unit root tests were conducted to establish data suitability, while Pedroni cointegration tests examined long-run relationships among variables. The Redundant Fixed Effects and Hausman tests guided the selection between Fixed Effect and Random Effect models. Model evaluation was based on R-squared, adjusted R-squared, F-statistic, t-statistics, and Durbin-Watson statistic. Statistical significance was determined at the 5% level, where probability values below 0.05 indicated significant effects.

The functional relationship between carbon credit accounting and climate change mitigation was expressed as:

$ERR_{it} = f(EIR_{it}, CCIR_{it}, REM_{it}, ELR_{it}, ENIR_{it}, GFR_{it})$

To facilitate empirical estimation, the functional form was transformed into an econometric panel regression model as follows:

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$ERR_{it} = \beta_0 + \beta_1 EIR_{it} + \beta_2 CCIR_{it} + \beta_3 REM_{it} + \beta_4 ELR_{it} + \beta_5 ENIR_{it} + \beta_6 GFR_{it} + \mu_i + \varepsilon_{it}$

Where ERRit denotes emissions reduction rate of firm *i* at time *t*, β_0 represents the intercept, β_1–β_6 are coefficients measuring the effects of EIR, CCIR, REM, ELR, ENIR, and GFR, μ_i captures firm-specific effects, and ε_{it} represents the error term.

RESULTS AND DISCUSSION

This section presents the data analysis procedures employed to examine the influence of carbon credit accounting on climate change mitigation among oil and gas firms in Nigeria. Data covering 2016–2025 were analysed using statistical and econometric techniques. Carbon credit accounting was measured using EIR, CCIR, REM, ELR, ENIR, and GFR, while ERR represented climate change mitigation. Panel data analysis was adopted to capture firm-specific and time-based variations. Descriptive statistics, correlation analysis, diagnostic tests, stationarity tests, cointegration tests, and model selection tests were conducted to determine relationships and identify the appropriate estimation model.

Descriptive Statistics

This test examined the characteristics, distribution, and patterns of EIR, CCIR, REM, ELR, ENIR, GFR, and ERR, providing preliminary insights into variable performance, variability, and consistency among firms.

Table 1: Descriptive Statistics

	ERR	EIR	CCIR	REM	ELR	ENIR	GFR
Mean	0.140709	0.202426	0.065353	0.257996	0.105750	0.315260	0.134511
Median	0.137250	0.190950	0.067800	0.282350	0.101500	0.310500	0.136550
Maximum	0.252300	0.350000	0.117900	0.448400	0.197700	0.599200	0.249800
Minimum	0.051200	0.057100	0.012200	0.050200	0.021200	0.100800	0.011900
Std. Dev.	0.045197	0.090965	0.030476	0.126098	0.048782	0.144627	0.073297
Skewness	0.351861	0.054260	0.049456	-0.288827	0.245457	0.194515	0.032970
Kurtosis	2.550457	1.649972	1.719620	1.745513	1.962901	1.848538	1.639536
Jarque-Bera	2.324375	6.114510	5.497191	6.358071	4.388569	4.924028	6.184034
Probability	0.312801	0.067017	0.064018	0.071626	0.111438	0.085263	0.075410
Sum	11.25670	16.19410	5.228200	20.63970	8.460000	25.22080	10.76090
Sum Sq. Dev.	0.161377	0.653695	0.073376	1.256150	0.187994	1.652430	0.424423
Observations	80	80	80	80	80	80	80

Source: E-Views 9.0 Output, 2026.

Table 1 presents the descriptive statistics for the 80 firm-year observations analysed in the study. The mean value of ERR was 0.140709, indicating an average emissions reduction performance of approximately 14.1% among sampled firms. The mean values of EIR, CCIR, REM, ELR, ENIR, and GFR revealed variations in carbon accounting practices. ENIR recorded the highest variability while CCIR had the lowest dispersion. The skewness and kurtosis results showed acceptable distributional characteristics of the variables. Furthermore, Jarque-Bera probability values above 0.05 confirmed normality and indicated that the dataset was appropriate for further panel least squares regression analysis and econometric model estimation.

Correlation Analysis

Examined the direction and strength of relationships among EIR, CCIR, REM, ELR, ENIR, GFR, and ERR, identifying associations and possible multicollinearity among explanatory variables.

Table 2: Correlation Analysis

	ERR	EIR	CCIR	REM	ELR	ENIR	GFR
ERR	1.000000						
EIR	0.132820	1.000000					
CCIR	0.076756	0.115228	1.000000				
REM	0.109017	0.046623	0.184668	1.000000			
ELR	-0.156070	0.133920	-0.063638	0.045509	1.000000		
ENIR	-0.061819	-0.227359	-0.174104	-0.086629	0.039575	1.000000	
GFR	-0.081099	-0.027425	-0.186465	-0.169902	-0.073637	-0.124681	1.000000

Source: E-Views 9.0 Output, 2026.

Table 2 presents the correlation analysis among the study variables, showing the relationships between ERR and the explanatory variables. ERR had positive but weak correlations with EIR (0.132820), CCIR (0.076756), and REM (0.109017), indicating slight direct associations. Conversely, ELR (-0.156070), ENIR (-0.061819), and GFR (-0.081099) showed weak negative relationships with ERR. The independent variables recorded low correlation values, with the highest between CCIR and REM (0.184668). Since all coefficients were below 0.80, the results confirmed the absence of serious multicollinearity, supporting regression analysis.

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Residual Cross-Sectional Dependence Test

Assessed whether common factors influenced firms' observations. A probability value below 0.05 indicated dependence, while above 0.05 confirmed independence.

Table 3: Residual Cross-Sectional Dependence Test

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: Untitled
Periods included: 10
Cross-sections included: 8
Total panel observations: 80
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	26.13808	28	0.5655
Pesaran scaled LM	-1.317854		0.1876
Pesaran CD	0.710001		0.4777

Source: E-Views 9.0 Output, 2026.

Table 3 presents the residual cross-sectional dependence test conducted to determine whether unobserved factors affected multiple firms within the panel dataset. The Breusch-Pagan LM, Pesaran scaled LM, and Pesaran CD tests recorded probability values of 0.5655, 0.1876, and 0.4777 respectively. Since all values exceeded the 0.05 significance level, the null hypothesis of no cross-sectional dependence was accepted. This indicates that residuals among sampled firms were independent, confirming the suitability of the panel least squares regression model for analysing the relationship between carbon credit accounting practices and emissions reduction performance.

Group Jarque-Bera Probability Test

The Group Jarque-Bera test assessed variable normality. Probability values above 0.05 confirmed normal distribution, while values below 0.05 indicated deviation from normality.

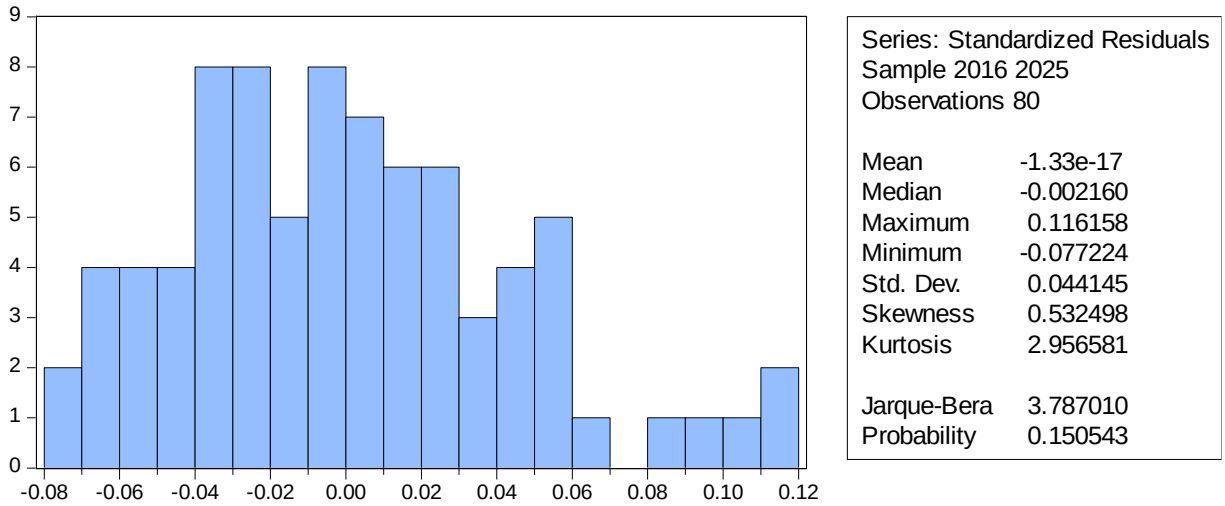


Figure 1: Group Jarque-Bera Probability Test
Source: E-Views 9.0 Output, 2026.

Figure 1 presents the Group Jarque-Bera probability test conducted to examine the normality of residuals in the panel regression model. The test was used to confirm whether the data satisfied the normality assumption required for reliable estimation. The result showed a probability value above the 0.05 significance level, leading to acceptance of the null hypothesis of normal distribution. This indicates that the residuals were normally distributed without significant deviations from normality. Therefore, the variables were considered suitable for further econometric analysis, supporting the reliability and validity of regression estimates on carbon accounting practices and emissions reduction performance.

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Panel Unit Root

This test examined stationarity of EIR, CCIR, REM, ELR, ENIR, GFR, and ERR. Probability values below 0.05 confirmed stationarity.

Table 4: ADF Panel Unit Root Test

Variables	**Method**	**ADF Statistics**	**Probability**	**@ Level**	**Check for Stationary**
ERR	ADF Test	22.4569	0.2187	1(0)	Non-Stationary
EIR	ADF Test	20.6240	0.1934	1(0)	Non-Stationary
CCIR	ADF Test	16.7596	0.2442	1(0)	Non-Stationary
REM	ADF Test	16.2684	0.1504	1(0)	Non-Stationary
ELR	ADF Test	23.6330	0.0761	1(0)	Non-Stationary
ENIR	ADF Test	23.7813	0.0944	1(0)	Non-Stationary
GFR	ADF Test	14.6009	0.3745	1(0)	Non-Stationary
Variables	**Method**	**Statistics**	**Probability**	**@1st Diff.**	**Check for Stationary**
ERR	ADF Test	89.0849	0.0000	1(1)	Stationary
EIR	ADF Test	76.1255	0.0002	1(1)	Stationary
CCIR	ADF Test	40.4718	0.0007	1(1)	Stationary
REM	ADF Test	41.6700	0.0004	1(1)	Stationary
ELR	ADF Test	34.7737	0.0043	1(1)	Stationary
ENIR	ADF Test	30.8068	0.0142	1(1)	Stationary
GFR	ADF Test	45.1418	0.0001	1(1)	Stationary

Source: E-Views 9.0 Output, 2026.

Table 4 presents the Augmented Dickey-Fuller (ADF) panel unit root test used to examine the stationarity of the study variables. At level, ERR, EIR, CCIR, REM, ELR, ENIR, and GFR were non-stationary as their probability values exceeded 0.05. However, after first differencing, all variables became stationary with probability values below 0.05. The null hypothesis of unit root was therefore rejected, confirming that all variables were integrated at order one, I(1). This result indicates that the variables were suitable for panel econometric analysis and reduced the possibility of spurious regression outcomes.

Pedroni Residual Cointegration Test

The cointegration test assessed long-run relationships between carbon credit accounting practices and climate change mitigation. Probability values below 0.05 confirmed cointegration.

Table 5: Pedroni Residual Cointegration Test

Pedroni Residual Cointegration Test
Series: ERR EIR CCIR REM ELR ENIR GFR
Date: 07/31/26 Time: 17:41
Sample: 2016 2025
Included observations: 80
Cross-sections included: 8 in non-parametric (PP) test; 0 (8 dropped)
parametric (ADF) test
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-2.688215	0.9964	-2.746448	0.9970
Panel rho-Statistic	3.545709	0.9998	3.649853	0.9999
Panel PP-Statistic	-1.705638	0.0440	-1.887224	0.0285
Panel ADF-Statistic	4.27814	0.0000	6.123940	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	4.836390	1.0000
Group PP-Statistic	-2.467978	0.0019
Group ADF-Statistic	4.193822	0.0000

Source: E-Views 9.0 Output, 2026.

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Table 5 presents the Pedroni residual cointegration test examining the long-run relationship among ERR, EIR, CCIR, REM, ELR, ENIR, and GFR. The Panel PP, Panel ADF, Group PP, and Group ADF statistics recorded probability values below 0.05, indicating rejection of the null hypothesis of no cointegration. Although Panel v and rho statistics did not confirm cointegration, the majority of results established a long-run equilibrium relationship among the variables. This implies that carbon accounting practices and emissions reduction performance of Nigerian oil and gas firms move together over time, supporting panel regression analysis.

Redundant Fixed Effects Tests Vs Correlated Hausman Test

The redundant fixed effects and Hausman tests identified the appropriate panel model by assessing firm-specific effects. Probability values below 0.05 supported fixed effects estimation.

Table 6: Redundant Fixed Effects Tests Vs Correlated Hausman Test

Redundant Fixed Effects Tests			
Equation: Untitled			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	12.389006	(7,66)	0.0000
Cross-section Chi-square	67.117710	7	0.0000
Correlated Random Effects - Hausman Test			
Equation: Untitled			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	2.296667	6	0.8905

Source: E-Views 9.0 Output, 2026.

Table 6 presents the redundant fixed effects and Hausman tests used to determine the appropriate panel regression model. The redundant fixed effects test recorded probability values of 0.0000, confirming significant firm-specific effects and supporting the use of panel estimation. However, the Hausman test produced a probability value of 0.8905, which exceeded the 0.05 significance level. This indicates that the random effects model was more appropriate than the fixed effects model. Therefore, the random effects estimation technique was selected to examine the relationship between carbon accounting practices and emissions reduction performance among Nigerian oil and gas firms.

Random Effects Regression

Random effects regression examined the influence of carbon credit accounting practices on climate change mitigation, considering firm differences as random. Coefficients below 0.05 indicated significant effects, while higher values showed insignificance.

Table 7: Random Effect Model

Dependent Variable: ERR
Method: Panel EGLS (Cross-section random effects)
Date: 07/31/26 Time: 17:35
Sample: 2016 2025
Periods included: 10
Cross-sections included: 8
Total panel (balanced) observations: 80
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.159320	0.028774	5.536841	0.0000
EIR	0.158532	0.043516	3.643074	0.0002
CCIR	0.123955	0.029998	4.132109	0.0000
REM	0.124114	0.029859	4.156670	0.0000
ELR	-0.150372	0.074554	-2.016958	0.0474
ENIR	-0.032376	0.027212	-1.189741	0.2380
GFR	-0.018372	0.051816	-0.354566	0.7239
	Effects Specification			
			S.D.	Rho
Cross-section random			0.050997	0.7250
Idiosyncratic random			0.031408	0.2750

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	Weighted Statistics		
R-squared	0.557276	Mean dependent var	0.026898
Adjusted R-squared	0.533901	S.D. dependent var	0.031133
S.E. of regression	0.030601	Sum squared resid	0.068357
F-statistic	8. 162031	Durbin-Watson stat	1.945846
Prob(F-statistic)	0.000000		
	Unweighted Statistics		
R-squared	0.545993	Mean dependent var	0.140709
Sum squared resid	0.523954	Durbin-Watson stat	1.506253

Source: E-Views 9.0 Output, 2026.

Table 7 presents the random effects regression results examining the effect of carbon accounting practices on emissions reduction performance among Nigerian oil and gas firms. The model was estimated using 80 balanced panel observations from 8 firms covering 2016–2025. The weighted R-squared value of 0.557276 indicates that 55.7% of variations in ERR were explained by EIR, CCIR, REM, ELR, ENIR, and GFR. The adjusted R-squared value of 0.533901 confirms model adequacy. The F-statistic (8.162031) with probability value 0.0000 shows overall significance, while the Durbin-Watson value (1.945846) indicates absence of serious autocorrelation.

The study revealed that EIR had a positive and significant effect on ERR, indicating that effective emission intensity management improves climate change mitigation among oil and gas firms in Nigeria. This finding supports Legitimacy Theory, as firms reduce emissions to maintain societal acceptance and demonstrate environmental responsibility. It also aligns with Stakeholder Theory because stakeholders demand improved emissions management. The result agrees with Eze et al. (2024), Suleiman et al. (2026), and Etim et al. (2025), who found that environmental accounting practices enhance sustainability performance and accountability. Thus, Ho_1 was rejected.

The findings showed that CCIR had a positive and significant effect on ERR, implying that effective carbon cost management improves emissions reduction performance. This supports Legitimacy Theory by showing that firms adopt carbon cost accounting to demonstrate environmental responsibility and maintain legitimacy. It also supports Stakeholder Theory, as transparent carbon cost information enhances stakeholder confidence. The finding agrees with Onoh and Ezeani (2024), Bala et al. (2024), and Okolie et al. (2022), who established that environmental cost management and accounting practices improve sustainability outcomes and organizational performance. Consequently, Ho_2 was rejected.

The study found that REM had a positive and significant effect on ERR, indicating that renewable energy adoption and improved energy diversification enhance climate change mitigation. The finding supports Legitimacy Theory because firms adopt cleaner energy practices to demonstrate environmental commitment. It also aligns with Stakeholder Theory, as stakeholders increasingly demand sustainable energy practices. The result agrees with Tonye (2025), Eze and Olatunji (2025), and Etim et al. (2025), who emphasized that ESG practices, renewable energy adoption, and green accounting contribute to improved sustainability performance. Hence, Ho_3 was rejected.

The study revealed that ELR had a negative but significant effect on ERR, suggesting that increased environmental liabilities constrain emissions reduction performance. This finding supports Legitimacy Theory because high environmental obligations may indicate legitimacy challenges arising from poor environmental practices. It also reflects Stakeholder Theory, as environmental failures may reduce stakeholder confidence and increase pressure on firms. The result agrees with Eze et al. (2024) and Suleiman et al. (2026), who emphasized the importance of environmental accountability and disclosure in improving sustainability performance. Accordingly, Ho_4 was rejected.

The findings indicated that ENIR had a negative but insignificant effect on ERR, suggesting that variations in energy intensity did not significantly influence emissions reduction performance among sampled firms. Although the result provides limited support for Stakeholder Theory, it implies that energy efficiency practices may not yet be sufficiently developed to produce measurable environmental outcomes. The finding differs from Eze and Olatunji (2025) and Etim et al. (2025), who highlighted the importance of efficient resource utilization and sustainable operations in improving environmental performance. Thus, Ho_5 was not rejected.

The study found that GFR had a negative but insignificant effect on ERR, indicating that variations in gas flaring activities did not significantly explain emissions reduction performance. The finding provides limited support for Legitimacy Theory and Stakeholder Theory because gas flaring reduction is expected to improve environmental responsibility and satisfy stakeholder expectations. However, the result differs from Bello and Yusuf (2024), who found that gas flaring reduction significantly improved climate change mitigation. The difference may be attributed to variations in regulatory enforcement and investment in gas recovery initiatives. Consequently, Ho_6 was not rejected.

CONCLUSION

The study examined the effect of carbon credit accounting on climate change mitigation among oil and gas firms in Nigeria. Using an ex-post facto design and longitudinal panel framework, data were obtained from annual reports, sustainability reports, and audited financial statements of 8 listed firms covering 2016–2025. Findings revealed that EIR, CCIR, and REM had positive and significant effects on ERR, while ELR had a negative but significant effect. ENIR and GFR had negative but insignificant effects. The study concluded that carbon credit accounting enhances climate change mitigation, corporate accountability, and sustainability performance, although effectiveness depends on implementation, technology, and regulatory support.

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RECOMMENDATIONS

Based on the findings, the following recommendations were made:

i. Since EIR positively and significantly influenced ERR, oil and gas firms should strengthen emission monitoring systems, adopt advanced carbon measurement technologies, and establish clear emission reduction targets.

ii. Based on the effect of CCIR on ERR, firms should improve carbon cost accounting by integrating carbon-related costs into strategic planning and investment decisions.

iii. Following the positive influence of REM on ERR, firms should increase investments in renewable energy technologies and cleaner energy alternatives.

iv. Since ELR negatively affected ERR, firms should adopt preventive environmental management strategies, improve risk assessment, and strengthen remediation activities.

v. Given the insignificant effect of ENIR on ERR, firms should enhance energy efficiency through technological improvements and operational modernization.

vi. Based on the insignificant effect of GFR on ERR, firms should strengthen gas flaring reduction measures through gas recovery, commercialization, and flare control technologies.

CONTRIBUTIONS TO KNOWLEDGE

The study had contributed to knowledge in the following ways:

i. The study had contributed by directly linking carbon accounting practices with ERR, thereby providing evidence on how accounting practices could influence measurable climate change mitigation outcomes.

ii. The study had contributed methodological knowledge by applying panel data techniques to examine firm-level variations in carbon accounting practices and emissions reduction performance over a ten-year period.

iii. The study had contributed by showing that different carbon accounting practices had different effects on climate mitigation outcomes.

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