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EFFECT OF GAS FLARING POLICIES ON ENVIRONMENTAL SUSTAINABILITY IN NIGER DELTA, NIGERIA

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ABSTRACT: Environmental sustainability represents a multidimensional construct encompassing the conservation, protection, and responsible management of natural resources and ecosystems. Rooted in ecological preservation, biodiversity conservation, environmental degradation and pollution mitigation, sustainability is shaped by both intrinsic and extrinsic factors. Yet, despite their significant contributions, environmental sustainability in the Niger Delta region of Nigeria has become a subject of concern as most of the communities are faced with high uncertainty and business failure rates. Therefore, this study examined the impact of gas flaring policy on environmental sustainability in the Niger Delta region of Nigeria. This study was conducted with the aid of an integrated theoretical framework derived from environmental justice and ecological modernisation theories, among others and survey research method for data collection. The study found that technology adoption and community participation statistically significant impact on environmental sustainability in Niger Delta region of Nigeria at 5% level of significance. While regulatory enforcement has a positive but insignificant impact on environmental sustainability in Niger

Delta region of Nigeria at 5% level of significant. The study concluded that gas flaring policy influences environmental sustainability in Niger Delta region of Nigeria. The study thus recommended among others that reviews and strengthen existing environmental regulations to address all potential environmental impacts of gas flaring comprehensively. This may require updating legislation, closing loopholes and incorporating stricter environmental standards.

Keywords: *Regulatory Enforcement, Technology Adoption, Community Participation, Environmental sustainability.*

Introduction

The energy sector remains the cornerstone of Nigeria’s economic structure, serving as a critical driver of national development, industrialization, and foreign exchange earnings (Umar et al., 2025). As one of Africa’s largest oil producers, Nigeria’s economic growth is deeply intertwined with the petroleum industry, which significantly influences its fiscal stability and global trade relations (Musa et al., 2025; Magaji et al., 2025). However, the country faces mounting challenges in reconciling economic expansion n with environmental sustainability, particularly within the Niger Delta region—the epicenter of oil exploration and production activities (World Bank, 2023; Bello et al., 2025; Sabiu & Magaji, 2024).

Recent global energy transitions toward renewable and low-carbon sources have intensified Nigeria's need to adopt sustainable energy governance practices that minimise environmental harm while maintaining economic productivity (Sadiq et al., 2025; Tanko et al., 2025). The International Energy Agency (2023) reports that many oil-producing nations experience severe ecological degradation due to poorly managed extraction processes, and Nigeria remains among the most affected. Continuous gas flaring—a byproduct of crude oil extraction—has significantly contributed to greenhouse gas emissions, air pollution, and habitat destruction across the Niger Delta, thereby threatening both ecological balance and human well-being (Magaji et al., 2024).

According to the African Development Bank (2023), Nigeria’s energy consumption is projected to rise by about 45% by 2040, a trend that could further exacerbate environmental degradation if current practices persist. This situation underscores the urgent need for effective gas flaring policies that align with global sustainability goals and environmental protection standards. Consequently, understanding how gas flaring policies influence environmental sustainability in the Niger Delta is essential for informing policy reforms and ensuring the long-term ecological and socio-economic stability of the region.

Environmental sustainability in Nigeria's petroleum sector has deteriorated alarmingly, marked by irreversible ecological damage and socio-economic instability. Over 546 million gallons of oil have been spilled in the Niger Delta since 1956 (NOSDRA, 2023), contaminating 65% of its wetlands (NCF, 2021) and destroying aquatic biodiversity critical to local fisheries. Concurrently, Nigeria remains the seventh-largest gas-flaring nation globally, emitting 7.4 billion cubic feet of gas in 2018 alone (PwC, 2019), exacerbating climate vulnerabilities (Suleiman et al., 2025). According to PwC's assessment, gas flaring cost the Nigerian economy ₦233 billion (US$761.6 million) in 2018, representing 3.8% of the global total costs of gas flaring that year. These trends reflect a deepening crisis: mangrove loss has accelerated by 12% annually since 2010, while air pollution-related respiratory illnesses in oil-producing communities have surged by 40% (UNDP, 2022). The degradation directly undermines Nigeria's commitments to the UN Sustainable Development Goals (SDGs) and Paris Agreement, threatening both ecological resilience and human security. The Niger Delta's environmental decline has intensified despite policy interventions. Oil spill frequency increased by 28% between 2015 and 2023, driven by aging infrastructure and sabotage (NOSDRA, 2023). Gas flaring reductions lag behind targets, achieving only 20% of the 2030 zero-flaring goal, despite the percentage of gas flared in Nigeria declining from 53% in 2001 to 10% in 2018 (PwC, 2019). Meanwhile, deforestation rates near inland basins have tripled as exploration expands, signaling risks of replicating Delta-like crises in new regions.

The main objective of this study is to examine the effect of gas flaring policies on environmental sustainability in Niger Delta of Nigeria.

Literature Review

Conceptual Literature Review

Gas Flaring Policies

Gas flaring policies refer to the set of laws, regulations, institutional frameworks, and enforcement mechanisms designed to control, reduce, or eliminate the routine burning of associated natural gas during crude oil extraction. In Nigeria, gas flaring has persisted for decades despite the existence of multiple regulatory instruments such as the *Associated Gas Re-injection Act (1979)*, the *National Gas Policy (2017)*, and Nigeria's commitment to the *World Bank Zero Routine Flaring by 2030 Initiative*. Conceptually, gas flaring policies aim to minimize environmental damage, protect public health, promote efficient resource utilization, and encourage cleaner energy transitions.

Within this study, gas flaring policy is operationalised through three interrelated dimensions: regulatory enforcement, technology adoption, and community participation. These dimensions capture not only the formal policy intentions but also the practical mechanisms through which policy outcomes influence environmental sustainability in oil-producing communities.

Regulatory Enforcement

Regulatory enforcement refers to the degree to which gas flaring regulations are effectively implemented, monitored, and enforced by relevant government agencies. Conceptually, enforcement encompasses compliance monitoring, penalties for violations, institutional capacity, and transparency in regulatory processes. Strong enforcement is expected to deter non-compliance by oil companies and compel adherence to environmental standards.

In the Niger Delta context, weak enforcement has been widely associated with persistent gas flaring, environmental degradation, and regulatory capture. Poor inter-agency coordination, limited technical capacity, political interference, and inadequate sanctions often undermine the effectiveness of existing regulations. Conceptually, regulatory enforcement serves as a critical institutional pathway through which gas flaring policies can translate into improved air quality, reduced greenhouse gas emissions, and ecosystem protection, thereby enhancing environmental sustainability**.**

Technology Adoption

Technology adoption refers to the extent to agencies or firms deploy modern, environmentally friendly technologies (Okon et al., 2025). Conceptually, this includes gas re-injection systems, gas-to-power technologies, liquefied petroleum gas (LPG) recovery, and other clean-energy innovations.

From a sustainability perspective, technology adoption is central to reducing carbon emissions, minimizing local air pollution, and promoting efficient resource use (Oluwalosijibomi et al., 2025). In the Niger Delta, limited adoption of such technologies has been linked to high operational costs, infrastructural deficits, and weak policy incentives. Conceptually, effective gas flaring policies should encourage or mandate technological innovation as a means of aligning industrial production with environmental sustainability objectives.

Community Participation

Community participation refers to the involvement of host communities in the design, implementation, monitoring, and evaluation of policies (Hafizu et al., 2025). Conceptually, it includes access to environmental information, stakeholder consultation, grievance mechanisms, and local participation in environmental decision-making processes (Aminu et al., 2025).

In the Niger Delta, exclusion of local communities from environmental governance has contributed to distrust, conflict, and weak policy outcomes. Community participation is conceptually linked to environmental sustainability through enhanced accountability, local environmental stewardship, and social legitimacy of regulatory actions. When communities actively participate, they can serve as informal monitors of gas flaring activities, report violations, and support sustainable environmental practices.

Environmental Sustainability

Environmental sustainability is a multidimensional concept that refers to the ability to maintain the integrity, resilience, and productivity of ecosystems while meeting present needs without compromising the ability of future generations to meet theirs (Abubakar et al., 2025; Conceptually, it encompasses pollution reduction, biodiversity conservation, ecosystem health, climate change mitigation, and sustainable resource management (Ibrahim et al., 2025).

In the Niger Delta, environmental sustainability is threatened by prolonged gas flaring, which contributes to air pollution, acid rain, soil infertility, water contamination, and loss of biodiversity. Within the framework of this study, environmental sustainability represents the dependent construct influenced by the effectiveness of gas flaring policies, particularly through regulatory enforcement, technology adoption, and community participation.

Conceptual Linkages

Conceptually, this study assumes that effective gas flaring policies enhance environmental sustainability by strengthening regulatory enforcement, promoting cleaner technologies, and fostering inclusive community participation. Regulatory enforcement provides the legal and institutional backbone, technology adoption offers practical solutions for emission reduction, while community participation ensures accountability and social legitimacy. The interaction of these elements determines the extent to which gas flaring policies can achieve sustainable environmental outcomes in the Niger Delta region.

Empirical Review

Ambituuni, et al, (2017) conducted a study on *Safety and Environmental Regulations for Downstream Petroleum Industry Operations in Nigeria, Problems and Prospects*, the study used a purposive sampling technique to select 120 respondents, including regulatory officers, oil company representatives, and community leaders across Rivers, Bayelsa, and Delta States. The study utilized both primary and secondary data. Primary data were collected through **structured** questionnaires and in-depth interviews, while secondary data were drawn from government policy documents, NOSDRA reports, and company environmental audit records. Quantitative data were analyzed using descriptive statistics and regression analysis, while qualitative data were analyzed through content analysis. The study found that weak regulatory enforcement and overlapping institutional functions have significantly undermined environmental sustainability in the Niger Delta. Regulatory agencies lacked adequate manpower and independence to ensure compliance, leading to widespread gas flaring and pollution. The authors concluded that without effective enforcement mechanisms and transparent sanctions, environmental sustainability goals will remain unattainable despite existing policy frameworks.

Emeseh (2021) analyzed environmental policy frameworks across 12 developing petroleum-producing countries to assess Nigeria's position within the comparative landscape. The research utilized a mixed-methods approach combining legal document analysis, expert surveys, and case study evaluations to develop a comprehensive policy effectiveness index. The study found that Nigeria's Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) ranked in the middle tier for policy comprehensiveness (scoring 6.8/10) but in the bottom quartile for implementation effectiveness (scoring 3.2/10), with particularly significant gaps in enforcement mechanisms and technical capacity. While methodologically robust, the study's reliance on expert assessments introduces potential subjective bias, and the aggregation of scores into composite indices may obscure important nuances in specific policy domains.

Ambituuni et al. (2014) investigated the implementation challenges in Nigeria's petroleum sector regulatory system. The study used a mixed-methods approach combining legal analysis, compliance data from 112 facilities, and key informant interviews. The research found that jurisdictional overlaps resulted in substantial enforcement gaps, with 41% of documented environmental violations receiving no enforcement response due to unclear agency responsibilities. Environmental inspectors were responsible for areas approximately 300% larger than international best practice recommendations, and only 42% of required monitoring technologies were available to enforcement personnel. Political interference was documented in 68% of major enforcement cases, undermining regulatory independence and effectiveness. The study's focus on downstream operations limits its applicability to upstream exploration activities, and it does not adequately distinguish between different types of regulatory violations.

Giwa et al. (2019) quantified the environmental and health impacts of gas flaring in the Niger Delta region. The research employed a quantitative methodology combining remote sensing data, atmospheric sampling, and dispersion modeling. The study documented approximately 35 million tons of CO_2 and other pollutants emitted annually through gas flaring, with black carbon concentrations exceeding World Health Organization guidelines in 83% of sampled locations around flaring sites. Communities within 5km of active flaring sites experienced 42% higher incidence of respiratory conditions compared to demographically similar communities beyond this range. The focus on atmospheric emissions addresses only one dimension of gas flaring impacts, overlooking effects on soil acidification, water quality, and vegetation, and the study provides limited temporal analysis to assess policy effectiveness over time.

Theoretical Framework

Sachs and Warner (1995) established Resource Curse Theory through econometric analysis of growth patterns across resource-rich and resource-poor countries. The study employed cross-national statistical analysis, economic modeling, and comparative case assessment. The research identified a paradoxical negative relationship between natural resource abundance and economic growth, with resource-rich countries growing more slowly than resource-poor countries despite their apparent advantage. Sachs and Warner demonstrated that this relationship remained robust even when controlling for various economic, geographic, and policy factors. While groundbreaking in establishing the statistical relationship, the study's primarily economic focus did not fully address the institutional and political mechanisms through which the resource curse operates.

Ross (2015) expanded Resource Curse Theory to examine political and institutional dimensions beyond economic effects. The research utilized multi-method analysis combining statistical assessment of 170 countries, process tracing in selected cases, and theoretical development. The study identified three primary causal mechanisms through which the resource curse operates: (1) the rentier effect, where governments derive sufficient revenue from resources to reduce accountability to citizens; (2) the repression effect, where resource revenues fund internal security apparatuses that suppress dissent; and (3) the modernization effect, where resource dependence impedes social and institutional changes associated with development. Ross demonstrated that these mechanisms operate with particular intensity in petroleum-dependent states, with oil-rich countries 50% more likely to be authoritarian and significantly more prone to weakened institutional quality. While providing valuable theoretical refinement, the study's broad comparative approach may obscure important contextual variations in how the resource curse manifests in specific countries like Nigeria.

Resource Curse Theory provides this study with analytical tools for understanding how Nigeria's heavy dependence on oil revenues has shaped governance incentives, institutional capabilities, and policy implementation patterns in ways that systematically undermine environmental sustainability objectives. The theory helps explain persistent implementation gaps across Nigeria's environmental policy landscape, where well-crafted policies frequently fail to translate into effective protection measures. Furthermore, its attention to how resource extraction creates opportunities for corruption and patronage politics illuminates the political economic

Methodology

This study adopts descriptive survey research design. Descriptive research aims to describe the characteristics of a population or phenomenon by collecting data through surveys, interviews, or observations. Survey research involves the use of standardized questionnaires or interviews to collect data from a sample of respondents that is representative of the target population Fowler Jr, (2013).

The population of this study comprised of five hundred and fifty (550) representatives of the selected stakeholders with knowledge, experience, or direct involvement in Nigeria's energy policy, oil exploration, and environmental management, particularly in the Niger Delta region. According to Chandan, et al, (2020), a sampling size is the number of sampling units selected from the population for investigation.

This study employed Taro Yamane sample formula (1968) to determine sample size.

$$n = \frac{N}{1+N(e)2}$$

Where n = sample size

N = Population

e = rate of error

N= 550

e= 0.05

$$n = \frac{550}{1+550(0.05)^2}$$

$$n = \frac{550}{1+550(0.0025)}$$

$$n = \frac{550}{1+1.375}, n=$$

n = 232

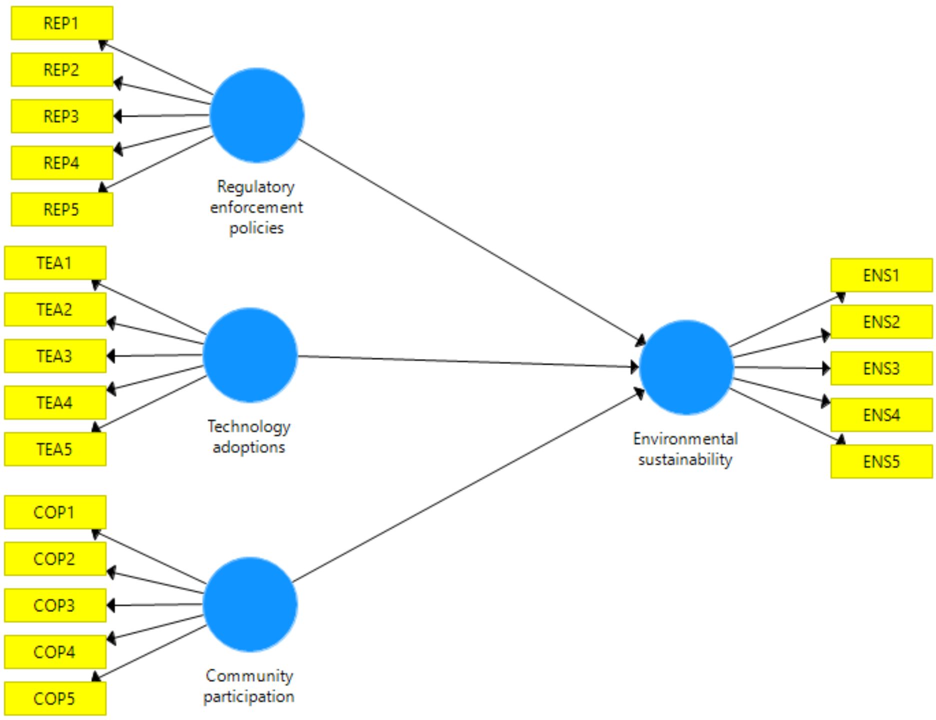

Fig. 1 The Model of the Study

The PLS-SEM analysis was conducted using the Smart PLS software, following a two-step approach. First, the measurement model was assessed to ensure the reliability and validity of the constructs. This step verified the accuracy of the measurement items for entrepreneurial leadership, strategic resource management, and business networking. Second, the structural model was evaluated to test the hypothesized relationships between energy policies and the environmental sustainability. This method allowed for a comprehensive examination of both direct and indirect effects, providing a deeper understanding of how various components of energy policies influence the environmental sustainability of the region.

However, the research process adhered to strict ethical standards. Informed consent was obtained from all participants, ensuring they were aware of the study's purpose and their right to withdraw at any time without repercussion. Confidentiality of the participants' responses was guaranteed, and all data was anonymized and securely stored to protect the privacy of the respondents. This approach ensured the integrity and ethical soundness of the research process.

Results and Discussions

Assessment of Measurement Model

Table 1: Convergent validity

Variables	Indicators	Factor Loadings	Cronbach's alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Environmental sustainability	ENS1	0.932	0.915	0.934	0.936	0.745
	ENS2	0.809				
	ENS3	0.838				
	ENS4	0.799				
	ENS5	0.927				
Technology Adoption	TA1	0.939	0.896	0.912	0.924	0.708

	TEA2	0.791				
	TEA3	0.821				
	TEA4	0.809				
	TEA5	0.934				
Regulatory Enforcement	REF1	0.864	0.880	0.897	0.912	0.677
	REF2	0.887				
	REF3	0.742				
	REE4	0.742				
	REF5	0.866				
Community Participation Policies	COP1	0.843	0.939	0.955	0.953	0.804
	COP2	0.900				
	COP3	0.883				
	COP4	0.918				
	COP5	0.937				

Source: Smart PLS Output, 2025

The Environmental sustainability variable shows strong internal consistency and reliability, with a Cronbach's alpha of 0.915, indicating excellent reliability. The Composite Reliability (CR) is 0.936, further confirming that the construct is reliable. The Average Variance Extracted (AVE) is 0.745, meaning that 74.5% of the variance in the performance indicators is explained by the latent construct, which suggests good convergent validity. Each indicator, such as ENS1 (0.932) and ENS5 (0.927), has high factor loadings, further validating that these items strongly represent the underlying performance construct. These results imply that the measurement of environmental sustainable is robust and reliable, which provides confidence that this variable accurately captures the intended performance-related aspects within the Niger Delta.

For the Technology Adoption construct, the Cronbach's alpha of 0.896 shows strong internal consistency. With a Composite Reliability (CR) of 0.924 and an AVE of

0.708, the construct demonstrates good reliability and convergent validity. The AVE indicates that 70.8% of the variance is explained by the technology adoption construct. Factor loadings, such as TA1 (0.939) and TA5 (0.934), are high, reinforcing the validity of the indicators in measuring hydrocarbon exploration policies. These findings suggest that technology adoption is a well-measured variable in this context, providing a reliable assessment of leadership affecting environmental sustainability.

The regulatory enforcement variable displays a Cronbach's alpha of 0.880, indicating high reliability. The Composite Reliability is 0.912, confirming the construct's consistency, while the AVE is 0.677, suggesting that 67.7% of the variance in regulatory framework is captured by the latent construct. Factor loadings, such as REF1 (0.864) and REF2 (0.887), show that these indicators strongly represent the construct, while REF3 and REF4 (both 0.742) show slightly lower but still acceptable loadings. These results imply that the construct of regulatory framework is measured reliably, although some indicators could potentially be refined for even stronger representation.

The community participation variable demonstrates the highest internal consistency, with a Cronbach's alpha of 0.939 and an extremely high Composite Reliability of 0.953. The AVE of 0.804 indicates that 80.4% of the variance is explained by the construct, confirming strong convergent validity. Factor loadings such as COP5 (0.937) and COP4 (0.918) are particularly high, indicating that these items are excellent indicators of the business networking construct. These results suggest that gas flaring is a well-defined and reliably measured construct in this study, playing a significant role in explaining sustainability in Niger Delta. The above results are shown in fig. 2 and table 1

Discriminate Validity

Table 2: Heterotrait-Monotrait Ratio (HTMT)

	Community participation policies	**Technology Adoption policies**	**Environmental sustainability**	**Regulatory Enforcement**
Community participation				
Technology adoption	0.596			

Environmental sustainability	0.329	0.416		
Regulatory enforcement	0.290	0.318	0.205	

Source: Smart PLS Output, 2025

Table 3 presents the Heterotrait -Monotrait Ratio (HTMT) results, which are crucial for assessing the discriminant validity of the constructs in the study. The Heterotrait-Monotrait Ratio (HTMT) values in the table are all well below the standard threshold of 0.85, indicating good discriminant validity between the constructs. Discriminant validity ensures that each latent variable in the model represents a unique concept. For example, the HTMT value between community participation and technology adoption is 0.596, confirming that these two constructs are perceived as distinct by the respondents. Similarly, Regulatory enforcement and Environmental sustainability have an HTMT value of 0.205, showing a clear distinction between regulatory enforcement and sustainability outcomes. This distinction is critical because it implies that the variables are independent enough to study how each uniquely affects the performance of environment without overlap.

The low HTMT values for all constructs suggest that the model can effectively differentiate between the constructs of Regulatory enforcement, Technology adoption, Community participation and Environmental Sustainability. For example, Environmental Sustainability shows values of 0.329 and 0.416 in relation to regulatory enforcement, and Technology adoption respectively, indicating that while there are relationships between these factors, they are distinct and can be evaluated separately. This distinction allows for a more precise understanding of how different energy policies contribute to Environmental sustainability. The findings ensure that the model is reliable and that any conclusions drawn from the relationships between these variables are based on well-defined and separate constructs, enhancing the robustness of the study's outcomes.

Path Coefficients

Table3: Path Coefficient

	Original Sample	Sample Mean	Standard Deviation	T Statistics (|O/STDEV|)	P Values

	(O)	(M)	(STDEV)		
REF -> ENS	0.282	0.285	0.065	4.330	0.000
TEA -> ENS	0.079	0.087	0.051	1.531	0.126
COP-> ENS	0.148	0.150	0.067	2.209	0.028

Source: Smart PLS Output, 2025

The Figure 3 and table 2 show that standard beta and the corresponding t-values were used in assessing the structural model in this study. It was done through the bootstrapping procedure.

i. **H_{O1}**: Technology adoption has no significant effect on the environmental sustainability in the Niger Delta region of Nigeria.

The bootstrapping result from the Smart PLS reveals that path coefficient of hydrocarbon exploration and environmental sustainability (TEA->ENS) is positive and statistically significant at 5% level of significant. The path coefficient from Technology adoption (TEA) to Environmental sustainability (ENS) is 0.282, with a T-statistic of 4.330 and a P-value of 0.000. These results indicate has statistically and positive effect on Environmental sustainability, as the P-value is less than 0.05, and the T-statistic is well above the critical value of 1.96. This means that effective Technology adoption significantly enhances the environmental sustainability in the region. Organizations who demonstrate strong technological skills can guide their teams more effectively, foster innovation, and make strategic decisions that improve overall relationship with the host communities. The implication here is that Technology adoption is a crucial factor in driving environmental sustainability success, and efforts to develop long time sustainability capabilities within the Niger Delta region that can lead to improved business outcomes. The finding is in line with the finding of Sawaean et al. (2021) who investigated the relationship between technological exploration and environmental sustainability in Kuwait and found that technical exploration had a significant positive impact on environmental sustainability. The finding is also in agreement with the finding of Tsetim et al. (2020) who examined the impact of technology on the environmental sustainability in Bayelsa State, Nigeria and significant relationships between all aspects of technological exploration (miner, explorer, accelerator, and integrator behaviors) and environmental sustainability.

H_{O2}: Regulatory enforcement has no significantly effect on the environmental sustainability in the Niger Delta region of Nigeria

For the second hypothesis, the result from the Smart PLS reveals that path coefficient of regulatory frameworks (REF) and environmental sustainability (REF->ENS) is positive but statistically insignificant at 5% level of significant. The path coefficient from regulatory enforcement (REF) to Environmental sustainability (ENS) is 0.079, with a T-statistic of 1.531 and a P-value of 0.126. Since the P-value is greater than 0.05, the relationship between Regulatory enforcement frameworks and environmental sustainability is not statistically significant in this model. The T-statistic being below the critical threshold of 1.96 further confirms that the impact of regulatory frameworks on environmental sustainability is weak or insignificant in this context. This implies that while regulatory enforcement frameworks is important, it may not be the sole driver of sustainability improvements for Niger Delta region, or that other factors (such as host communities engagement) may be moderating this relationship. The finding is in disagreement with the finding of Riana et al. (2020) who investigated the influence of regulatory enforcement and competitive strategy on the environmental sustainability in Bali, Indonesia and found that regulatory frameworks strategic have a positive and significant effect on the environmental sustainability in Bali, Indonesia

H_{03}: Community participation has no significant effect on the environmental sustainability in the Niger Delta region of Nigeria

The bootstrapping result from the Smart PLS reveals that path coefficient of Community participation (COP) and environmental sustainability (COP->ENS) is positive and statistically significant at 5% level of significant. The Community participation (COP) to Environmental sustainability (ENS) is 0.148, with a T-statistic of 2.209 and a P-value of 0.028. This shows that community participation has statistically significant and environmental sustainability, as the P-value is below the 0.05 threshold. The T-statistic further confirms this significance by exceeding the critical value of 1.96. This finding suggests that effective community participation contributes positively to environmental sustainability, potentially by providing access to valuable resources, market information, and partnerships. For the host community in Niger Delta, fostering strong networks with oil companies, and other stakeholders can be a key strategy to enhance performance and seize business opportunities. The finding is in tending with the finding of Adudu et al. (2021) who assessed the impact of community participation on the environmental sustainability in Rivers State, Nigeria and found that all three network factors positively and significantly impacted environmental sustainability Specifically, network structure had the highest influence on sustainability, followed by network governance and content.

Multicollinearity Test

Table 5: Inner VIF Values

	Environmental sustainability
Technology adoption	1.448
Regulatory enforcement policies	1.109
Community participation	1.434

Source: Smart PLS Output, 2025

Table 5 presents the Inner Variance Inflation Factor (VIF) values for the structural model of the study and it shows the VIF values for the three predictor constructs The Inner VIF (Variance Inflation Factor) values in the table measure the level of multicollinearity between the independent variables, with values above 5 indicating potential multicollinearity issues. In this case, the VIF values for Technology adoption (1.448), Regulatory enforcement (1.109), and Community participation policies (1.434) are all well below the threshold of 5, indicating low multicollinearity among the variables. This means that the independent variables technology adoption, regulatory enforcement and community participation are not highly correlated with each other and are providing unique contributions to explaining the environmental sustainability. The implication is that the model is stable, and each variable's effect on environmental sustainability can be interpreted independently, which strengthens the validity of the results.

R Square

Table 6: R Square

	R Square	**R Square Adjusted**
Environmental sustainability	0.172	0.165

Source: Smart PLS Output, 2025

Table 6 presents the R Square values for the structural model, specifically focusing on the endogenous variable environmental sustainability. These values show the explanatory power of the model in the context of environmental sustainability in Niger Delta. The R Square (R^2) value of 0.172 indicates that 17.2% of the variance in the environmental sustainability is explained by the independent variables technology adoption, regulatory enforcement and community participation. The R Square Adjusted value of 0.165 accounts for the number of predictors in the model, slightly adjusting for potential overfitting. This suggests that, after accounting for the number of predictors, about 16.5% of the variation in environmental sustainability can still be explained by these factors.

While the R^2 value indicates that the model has some explanatory power, the relatively low value suggests that other factors not included in the model may also significantly influence environmental sustainability. In other words, technology adoption, regulatory enforcement and community participation are important, but they do not fully capture all the drivers of environmental sustainability. Future research or models could incorporate additional variables to better explain the remaining 82.8% of variance in performance.

Effect Size

Table 7: F Square

	Environmental sustainability
Technology adoption	0.167
Regulatory enforcement policies	0.007
Community participation	0.018

Source: Smart PLS Output, 2025

Table 7 presents the f-square values, which are essential for assessing the effect size of the predictor variables (Technology adoption) on the endogenous variable (environmental sustainability) in Niger Delta. The F Square values in the table assess the effect size of the independent variables (Technology adoption, regulatory enforcement and community participation) on the environmental sustainability. The value for Technology adoption is 0.167, indicating a moderate effect size, meaning that technology adoption has a meaningful impact on the environmental sustainability. Regulatory enforcement has an F Square value of 0.018, suggesting a small effect size, which means it has a minor but positive influence on environmental sustainability. On the other hand. Community participation shows an F Square value of 0.007, indicating a negligible effect size, suggesting that community participation has little to no significant impact on environmental sustainability within this model.

Model Fit

Table 8: Fit Summary

	Saturated Model	**Estimated Model**
SRMR	0.068	0.068
d_ULS	0.980	0.980
d_G	3.156	3.156
Chi-Square	3,050.737	3,050.737
NFI	0.584	0.584

Source: Smart PLS Output, 2025

Table 8 presents the Fit Summary for both the saturated and estimated models in the study. The Fit Summary table presents various fit indices for the structural model. The SRMR (Standardized Root Mean Square Residual) value is 0.068 for both the saturated and estimated models, which is below the acceptable threshold of 0.08, indicating a good model fit. The d_ULS and d_G values, which represent the squared Euclidean distance and geodesic distance, respectively, are 0.980 and 3.156, showing the consistency between the models. The Chi-Square value of 3,050.737 suggests that while there is some discrepancy between the observed and expected covariance matrices, it is common for large samples, so this alone does not invalidate the model.

The NFI (Normed Fit Index) value of 0.584 is relatively low, implying that while the model fits, there may be room for improvement in the overall fit when compared to the null mode.

Conclusion and Recommendations

The study examined the effect of gas flaring policies on environmental sustainability in Niger Delta of Nigeria, the study concludes that technology adoption and community participation policies significantly and positively influence the environmental sustainability in the region. This implies that authority concern with technology activities and community participation are prevalent, necessitates stringent regulations, effective enforcement, the adoption of best environmental practices, and a decisive transition towards cleaner energy sources to mitigate the severe ecological consequences of hydrocarbon extraction in Niger Delta region of Nigeria. On the other hand, regulatory enforcement frameworks policies, while showing a positive relationship with environmental sustainability, was found to have an insignificant effect. This suggests that these frameworks supposed to have introduces essential safeguards and pollution control measures, their impact is limited by factors such as weak enforcement, inadequate scope, economic pressures, and the inherent risks of the industry. To achieve a substantial positive influence in areas like the Niger DeltaBased on the findings and conclusion made in this study, the following recommendations are proposed:

i. Implement and rigorously enforce comprehensive environmental regulations specific to technology adoption and extraction activities. This includes stringent standards for waste management, emissions control, water discharge, and land rehabilitation.
ii. Review and strengthen existing environmental regulations to address all potential environmental impacts of gas flaring comprehensively. This may require updating legislation, closing loopholes, and incorporating stricter environmental standards.
iii. Implement comprehensive health monitoring programs in communities affected by gas flaring and provide appropriate medical support and

mitigation measures for respiratory and other health issues linked to air pollution.

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