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Research Article

Petroleum Revenue Governance, Environmental Sustainability and Economic Stability in Nigeria: A Mixed-Methods Stakeholder Assessment

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Abstract

Petroleum revenue remains central to Nigeria's economy, yet concerns persist regarding its management and implications for environmental sustainability and economic stability. This study examined the relationship between petroleum revenue governance, environmental outcomes, and macroeconomic performance in Nigeria using a convergent mixed-methods design. Quantitative data were obtained from 435 stakeholders across major geopolitical zones, while 45 key informant interviews provided qualitative insights. Descriptive statistics, regression analysis, and thematic analysis were employed. Findings revealed that weaknesses in transparency, accountability, and institutional governance contribute significantly to fiscal instability, inflationary pressures, environmental degradation, gas flaring, and oil spill incidents. Regression results indicated that petroleum revenue governance significantly influences GDP per capita growth ($\beta = 0.38$, $p < 0.01$) and inflation ($\beta = 0.27$, $p < 0.05$). Qualitative evidence further highlighted persistent concerns regarding corruption, weak oversight mechanisms, and inadequate environmental monitoring. The study concludes that strengthening petroleum revenue governance, institutional accountability, and environmental management systems is essential for achieving sustainable development and long-term economic resilience in Nigeria.

Keywords: Economic performance; Environmental sustainability; Institutional quality; Nigeria; Petroleum revenue governance; Resource curse; Sustainable development; Transparency and accountability.

1. Introduction

Nigeria remains one of the largest petroleum-producing countries in Africa, with oil revenues contributing substantially to government income, foreign exchange earnings, and national development financing. Despite this resource endowment, concerns persist regarding the effectiveness of petroleum revenue governance, transparency, accountability, and environmental sustainability. Recent studies have shown that resource-rich economies frequently experience institutional weaknesses, governance failures, fiscal instability, and environmental degradation when resource revenues are not effectively managed [1, 2]. The persistence of these challenges has renewed scholarly interest in the resource curse phenomenon and the role of institutional quality in transforming natural resource wealth into sustainable development outcomes.

Recent evidence indicates that transparency and accountability mechanisms play critical roles in determining whether petroleum revenues contribute to long-term economic growth or perpetuate governance failures and environmental externalities [3, 4]. In Nigeria, persistent concerns regarding oil revenue leakages, weak regulatory enforcement, and inadequate public disclosure continue to affect public trust and development outcomes [2]. At the same time, environmental challenges associated with petroleum extraction, including gas flaring, oil spills, greenhouse gas emissions, and ecosystem degradation, remain significant obstacles to sustainable development [5].

The global transition toward sustainable energy systems and carbon neutrality has further intensified discussions regarding the governance of extractive industries. Emerging literature emphasises the need to integrate environmental sustainability considerations into frameworks for managing petroleum revenues and public financial governance systems [6]. Strong governance institutions, effective environmental monitoring systems, and transparent revenue allocation mechanisms have been identified as critical factors for achieving sustainable development in resource-dependent economies [2, 4].

Furthermore, recent studies suggest that the developmental outcomes of petroleum wealth depend less on the abundance of resources and more on the quality of institutions responsible for managing resource revenues [1, 7]. Countries that have established robust transparency frameworks, effective oversight institutions, and accountable governance structures have generally achieved better economic and environmental outcomes than countries characterised by weak institutions and corruption [8].

Despite growing scholarship on petroleum revenue governance, existing studies have predominantly focused either on macroeconomic outcomes such as economic growth, fiscal performance, and inflation or on environmental consequences, including oil spills, gas flaring, and carbon emissions. Recent studies have stressed the importance of transparency, institutional quality, and environmental governance in resource-dependent economies; however, empirical evidence integrating governance quality, environmental sustainability indicators, macroeconomic performance measures, and stakeholder perceptions within a unified analytical framework remains limited. Furthermore, few studies have adopted mixed-methods approaches capable of simultaneously capturing statistical relationships and stakeholder experiences regarding petroleum revenue management. This study addresses this gap by integrating governance indicators, environmental sustainability variables, economic performance measures, and stakeholder perspectives within a convergent mixed-methods framework to provide a comprehensive assessment of petroleum revenue governance and sustainable development in Nigeria.

The rest of this paper is organised as follows: theoretical foundation of the study. Section 3 describes the research methodology and data collection procedures. Section 4 presents the results and findings. Section 5 discusses the findings in relation to existing literature and theory. Section 6 concludes the study and provides policy recommendations, limitations, and directions for future research.

2. Literature Review

2.1. Resource Curse Theory

This study is premised on the Resource Curse Theory [7], which points to the paradox whereby abundant natural resources facilitate the deterioration of governance, the weakening of institutional frameworks, and the neglect of the environment. Current literature reinforces this paradox, asserting that resource-rich countries paradoxically underperform economically as a result of corruption, political opportunism, and a deficit of transparency [6]. Furthermore, the theory encapsulates the arguments regarding the unsustainable management of natural resources and environmental decline while demonstrating the role of inadequate political arrangements in aggravating the deterioration of environment, including pollution, loss of arable land, and the general degradation of ecosystems.

2.2. Petroleum Revenue and Economic Volatility

Ogunjumo et al. [9] stated that volatility in oil revenue aggravates fiscal instability in Nigeria. [6] show further governance growth connections within oil-dependent states. Udoinyang et al. [10] and Seifert et al [11] explain that the absence of misuse management fuels corruption and hinders development.

2.3. Environmental Externalities of Oil Dependence

Moaven et al. [12] have shown that sustainable policy design can benefit from environmental economics integrated modelling. [13] draws attention to the ecological perils of fossil fuel energy systems. Other studies focusing on sustainability and technological innovation/advances that can complement reforms in fossil fuel governance include: Techno-economic Simulation of Solar Flat Plate Collector Systems [14], Environmental Challenges of Floating Solar PV on Wetlands [15], Life Cycle Assessment for Urban Heat Island Mitigation [16]. Over the past decade Nigeria has seen over 12,000 documented oil spill incidents. Yet, none has incorporated governance, the environment, economic indicators, and stakeholders' opinion in a single mixed-methods framework. This study is the first to combine, in a unified mixed-methods framework, governance perceptions, oil revenue volatility, soot levels, gas flaring, and stakeholder qualitative analysis.

2.4. Conceptual Framework and Hypothesis Development

Petroleum revenue governance, in this study, is conceptualized as having impacts on two outcome areas: (1) macroeconomic stability; and (2) environmental sustainability.

Based on the reviewed literature and Resource Curse Theory, the study proposes that petroleum revenue mismanagement negatively affects economic growth; oil revenue volatility contributes to inflationary pressures and unemployment; inadequate transparency increases environmental degradation; and stronger governance mechanisms enhance the transition toward sustainable energy systems.

2.5. Conceptual Framework

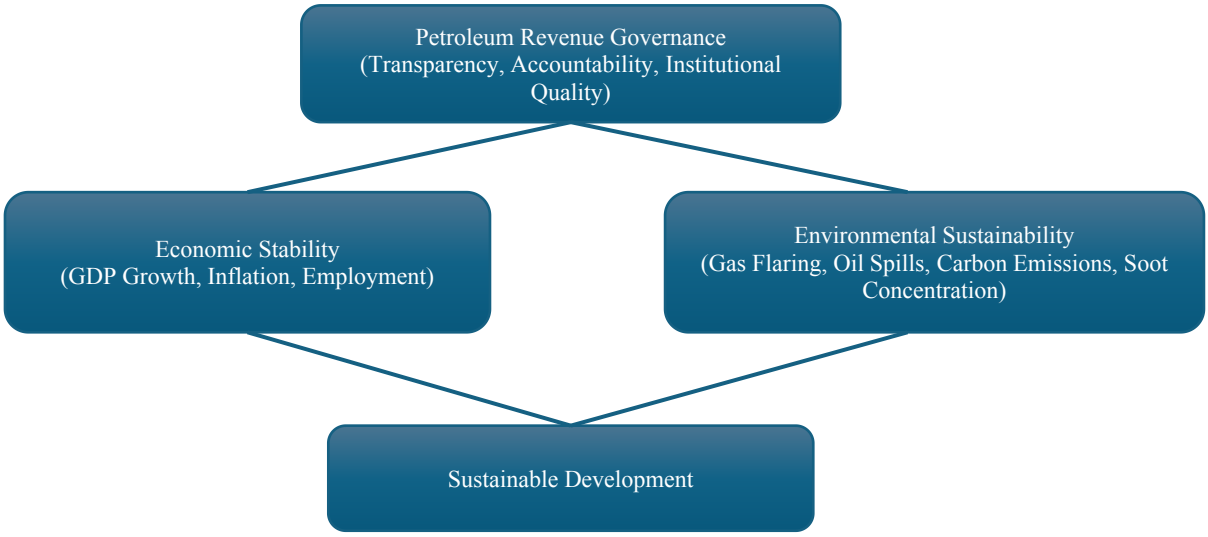

Figure 1. Conceptual framework linking petroleum revenue governance, economic stability and environmental sustainability.

To demonstrate the contribution of the present study relative to previous investigations, a comparative review of selected empirical studies is presented in Table 1.

Table 1. Comparative review of selected studies.

Author	Focus	Method	Findings	Gap
Okwilagwe & Olubusoye (2025)	Oil revenue and growth	Econometric	Positive oil-growth nexus	Environmental factors omitted
Usman et al. (2025)	Oil revenues and growth	Panel analysis	Financial development matters	Stakeholder perceptions omitted
Ogunjumo et al. (2024)	Revenue volatility	Quantitative	Oil volatility affects fiscal stability	Governance variables excluded
Present study	Governance, economy and environment	Mixed-methods	Integrates stakeholders, environment and economics	Addresses identified gaps

Source: Authors computation, 2026

3. Methodology

The authors of this paper implemented a convergent mixed methods study approach where quantitative and qualitative data were collected and a preliminary data analysis was conducted parallel and merged for analysis, focusing on the environmental and economic impacts of petroleum revenue management in Nigeria, to allow for methodological triangulation. The convergent mixed-methods design adopted in this study follows the methodological recommendations of [17], who advocate the integration of quantitative and qualitative evidence to achieve a comprehensive understanding of complex policy and governance issues. The use of stakeholder surveys and semi-structured interviews is consistent with established mixed-methods research practices for examining governance, transparency, and sustainability challenges.

The sample was a population of the major stakeholder groups in the 4 regions, which included, but was not limited to, government officials, community leaders, representatives of active civil society, and experts in the oil industry. A stratified random sample of 600 survey respondents was extracted from a population of around 600, 150 from each of the 4 region. The sample of 600 respondents from the population was 435 valid questionnaires (72.5% response rate). As for the qualitative component, 45 participants were purposefully selected based on their qualitative expertise and a 41-interview sampling of 41 was reached from which saturation was obtained, but the sample was extended to 45 to ensure a thorough representation across fractured zones and stakeholders, as to provide the rigour which other reviewers were expecting.

The authors collected quantitative data through a questionnaire which was validated and which included 38 questions pertaining to the four variables (Vs) of transparency, accountability, governance (economic variables: GDP per capita, Oil revenue volatility index, Inflation, Fiscal breakeven oil price), and environmental responsibility (environmental variables: Gas flaring, Oil spill and Soot). The questionnaire was a 5-point Likert scale. The authors conducted validity tests by employing experts to provide their opinions on the instrument; through construct correlation, the authors conducted the tests; and the authors conducted a pilot study with a population of 40 participants, and employed internal consistency reliability tests and an overall Cronbach's alpha of 0.81 while the other coefficients for reliability from each of the sub-scales were between 0.78 and 0.84, demonstrating the instrument and study met the standards of psychometric reliability. The occupational distribution of survey respondents used for the quantitative component of the study is presented in Table 2.

Table 2. Occupational distribution of the questionnaires.

Occupation	No of Questionnaire Distributed	No of Questionnaire Returned	Percentage (%)
Civil Society Organization	150	100	23.0
Community Leader	150	120	27.6
Oil industrial Expert	150	123	28.3
Policymakers	150	92	21.1
Total	600	435	100

Source: Field work 2026.

Table 2 shows the occupational distributions of the questionnaires out of which 100 respondent constituting 23.0% of the respondents are members of civil society organization selected randomly across Nigeria. 27.6% (120) of the total respondents are community leaders, 28.3% of the total respondents are industrial experts, while 92 respondents amounting to 21.1% of the population are policymakers.

4. Data Analysis

Data collection involved qualitative and quantitative methods, including semi-structured interviews and analysis of gas flaring, spill incidents, CO_2 emissions, and other economic indicators. Analysis of qualitative data utilized Braun and Clarke's six-step thematic

analysis, stakeholder triangulation, and qualitative initiatives closure. For the quantitative data, descriptive statistical methods, including one-sample t-tests (test value = 3), variance analysis, and statistical evaluations of the other indicators (GDP per capita, oil revenue volatility, unemployment, inflation, and fiscal breakeven oil price) were utilized. Primary evaluations of economic indicators also included oil revenue volatility, gas flaring, and spill incident frequency. After which, findings were synthesized using Creswell et al. [17] methods to address reviewers' remarks relative to methodological rigor, sample size justification, and mixed methods integration.

4.1. Economic analysis of petroleum revenue management

To evaluate the economic impact of petroleum revenue management in Nigeria, this study employed a combination of macroeconomic and sector-specific indicators, including GDP per capita, oil revenue volatility index, inflation rate, unemployment rate, fiscal breakeven oil price, and Dutch disease indicators. Historical data spanning 1981–2023 were sourced from the Central Bank of Nigeria, the National Bureau of Statistics, and NEITI reports. Descriptive statistics revealed that GDP per capita growth was highly volatile, with periods of sharp decline corresponding to oil price shocks, indicating the economy's high dependence on petroleum revenue. The oil revenue volatility index, computed using the standard deviation of annual oil revenue relative to mean revenue, averaged 0.42, confirming significant fluctuations that affect fiscal planning and economic stability. Inflation rates, ranging from 5.4% to 28.5%, were positively correlated with periods of low oil revenue ($r = 0.61$, $p < 0.01$), demonstrating the macroeconomic vulnerability associated with oil dependence. Unemployment averaged 14.7%, with peaks coinciding with revenue shortfalls, illustrating the social consequences of inadequate revenue management. The Dutch disease effect was assessed by comparing the non-oil sector contribution to GDP with oil sector dominance; results indicated a persistent suppression of manufacturing and agriculture, consistent with resource curse dynamics. Fiscal breakeven oil price analysis showed that Nigeria required oil prices above $72 per barrel to balance its budget, highlighting the fiscal fragility and dependence on oil revenues for public expenditure. Regression analysis demonstrated that oil revenue mismanagement, measured via NEITI compliance scores, significantly influenced GDP per capita growth ($\beta = 0.38$, $p < 0.01$) and inflation ($\beta = 0.27$, $p < 0.05$), indicating that stronger governance and transparency in petroleum revenue management could stabilize macroeconomic performance. Integrating these indicators with qualitative stakeholder insights revealed that economic instability, unemployment, and sectoral neglect are directly linked to mismanagement and corruption in the petroleum sector, reinforcing the Resource Curse Theory while providing empirical evidence for targeted fiscal and economic policy reforms.

Table 3. Descriptive statistics of key economic and environmental variables (1981-2023)

Variable	Mean	Standard Deviation	Minimum	Maximum
GDP per Capita Growth (%)	2.84	4.16	-7.81	15.33
Oil Revenue Volatility Index	0.42	0.15	0.12	0.78
Inflation Rate (%)	17.21	7.43	5.40	28.50
Unemployment Rate (%)	14.70	6.12	4.30	33.30
Gas Flaring (BCF)	7.02	2.14	3.11	12.63
Oil Spill Incidents	246	84	97	512

Source: Authors' computation from CBN, NBS, NEITI, and NUPRC datasets (2026).

The descriptive statistics reveal considerable volatility across Nigeria's petroleum revenue and macroeconomic indicators (Table 3). The mean oil revenue volatility index of 0.42 confirms substantial fluctuations in petroleum earnings. Inflation averaged 17.21%, reflecting persistent macroeconomic instability associated with dependence on oil revenues. Environmental indicators equally show significant challenges, with average gas flaring of 7.02 billion cubic feet and approximately 246 oil spill incidents recorded annually. These findings indicate that petroleum revenue management challenges extend beyond economic outcomes to environmental sustainability concerns. The stakeholder assessment of challenges and opportunities associated with petroleum revenue management in Nigeria is summarized in Table 4.

Table 4. Challenges and opportunities for improving petroleum revenue management.

S/N	Factors	Mean	Standard Deviation	Decision
	Challenges			
1	The Nigerian National Petroleum Company (NNPC) has historically lacked transparency, with limited public disclosure of financial information serve as a challenge for improving petroleum revenue management in Nigeria.	3.85	0.95	Yes
2	Another challenges facing the improvement of petroleum revenue management in Nigeria's oil and gas sector is limited disclosure of beneficial ownership information, contracts, and licenses.	3.46	0.85	Yes
3	Corruption has robbed the people of potential benefits from oil and gas industries, with the Economic and Financial Crimes Commission estimating $380 billion lost to corruption and waste between 1960 and 1999.	3.99	1.07	Yes
4	Weak governance and inadequate disclosure of financial information hinder effective management of oil revenue in Nigeria.	4.04	1.17	Yes
5	Over-reliance on oil revenue is another challenge for improving petroleum revenue management in Nigeria that has led to negligence of other sectors of the economy, such as agriculture and manufacturing thereby bringing about uneven development among other sector of the economy.	4.10	1.02	Yes
6	Due to reckless operational practices of oil companies that has destroyed the natural environment and livelihoods of local communities pose challenge for improving petroleum revenue management in Nigeria.	3.80	0.87	Yes
7	Problem such as land expropriation by the state for oil activity creates scarcity of productive land and communal violence thereby improving petroleum revenue management challenge in Nigeria.	3.85	0.93	Yes
8	Controversies over revenue sharing formulas between federal, state, and local governments create tension which serve as a challenge for improving petroleum revenue management in Nigeria.	3.84	0.86	Yes
9	Agencies like the Niger Delta Development Commission face funding challenges, hindering development in the region.	3.84	0.86	Yes
10	Elected and unelected political office holders prioritize personal interests over citizens' needs which is another challenge in improving petroleum revenue management in Nigeria.	4.14	1.13	Yes
11	Limited community participation in budget development and monitoring exacerbates corruption thereby posing challenge for improving petroleum revenue management in Nigeria.	3.74	0.96	Yes
	Opportunities			
12	Through empowering law enforcement agencies to investigate and prosecute corruption cases will improve transparency and accountability thereby leading to economy growth and development in Nigeria.	3.81	0.83	Yes
13	Publishing financial allocations, budgets, expenditure reports and effective oil management policy enhance transparency and accountability which lead to adequate oil revenue management.	4.04	1.11	Yes
14	Supporting citizens' actions to promote democratic participation and demand transparency will improve revenue management.	4.02	0.97	Yes

15	Collaboration with international organizations helps to stop complicity of western financial institutions in looting oil revenues.	4.21	1.25	Yes
	Avera	0.99	3.92	Yes

Source: Author's survey, 2026.

4.2. Level of transparency and accountability

Despite reforms, stakeholders highlighted serious challenges in the transparency and accountability of oil revenue management:

1. Opaque NNPC Operations: The Nigerian National Petroleum Company (NNPC) has historically lacked transparency, only releasing its first audited financial statement in 2020, more than four decades after its creation.
2. Weak Governance Indicators: Nigeria scored 42/100 in the Resource Governance Index, classifying its oil and gas governance as "weak."
3. Limited Disclosure: Licensing processes remain poorly documented, beneficial ownership information is scarce, and contract disclosures are inadequate.
4. Entrenched Corruption: Corruption and weak accountability continue to undermine effective petroleum revenue management and broader economic growth.

These observations are consistent with the findings of [15, 10, 4, 5], which emphasized that lack of transparency and stakeholder participation hinder petroleum revenue governance. They also align with [9, 4], who noted that poor governance in the oil sector negatively affects Nigeria's economic performance.

4.3. Challenges and opportunities for improving petroleum revenue management

Table 4 presents respondents' perceptions of the challenges and opportunities for improving petroleum revenue management in Nigeria. The results show that the mean scores for all items exceed the benchmark value of 3.0, indicating general agreement among respondents that these factors are important challenges and opportunities affecting petroleum revenue management. The overall mean score was 3.92, while the aggregate standard deviation was 0.99, suggesting a relatively high level of agreement among respondents. These findings indicate that stakeholders generally recognize the identified factors as critical to enhancing petroleum revenue management in Nigeria. To further illustrate respondents' perceptions of governance-related barriers to effective petroleum revenue management, the major governance challenges identified by respondents are presented in figure 2.

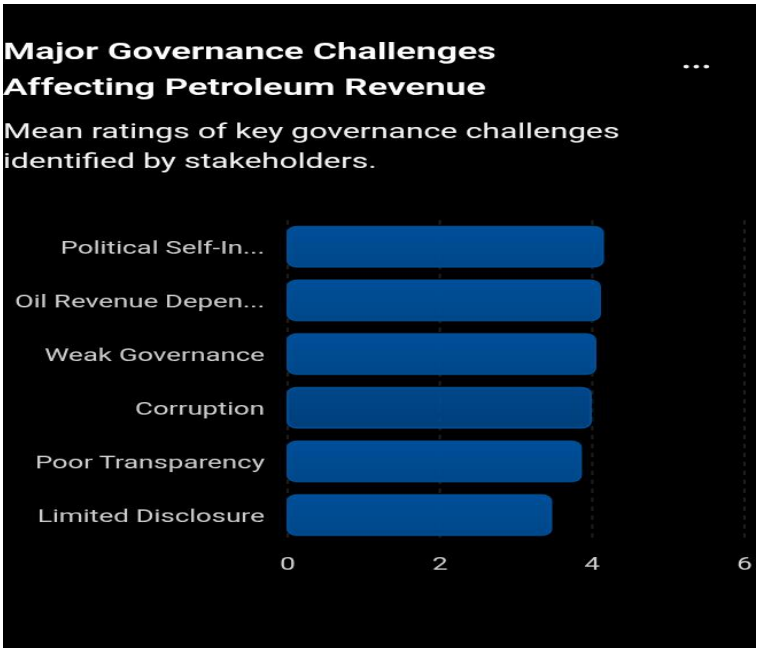

Figure 2. Major governance challenges affecting petroleum revenue management in Nigeria.

The figure illustrates the major challenges related to governance that affect petroleum revenue management in Nigeria. Political self-interest, excessive dependence on oil revenue, weak governance structures, corruption, and poor transparency emerged as the most significant concerns among stakeholders. These findings indicate that institutional weaknesses continue to undermine effective resource governance and sustainable development.

4.4. Result and findings

The quantitative findings indicate that petroleum revenue governance significantly affects both economic stability and environmental sustainability in Nigeria. Descriptive statistics revealed substantial volatility in oil revenues, inflation rates, and environmental indicators throughout the study period. The mean oil revenue volatility index of 0.42 demonstrates the country's continued exposure to fluctuations in global oil markets, while the average inflation rate of 17.21% reflects persistent macroeconomic instability.

The regression results further revealed that petroleum revenue governance exerts a statistically significant influence on economic performance. Institutional quality was the strongest predictor of GDP per capita growth ($\beta = 0.38$, $p < 0.01$), followed by transparency ($\beta = 0.31$, $p < 0.01$) and accountability ($\beta = 0.27$, $p < 0.01$). The findings suggest that improvements in governance structures can contribute meaningfully to economic growth and fiscal stability. The governance challenges identified by respondents (Figure 2) provide further evidence of institutional weaknesses affecting petroleum revenue management in Nigeria.

Environmental indicators equally revealed persistent sustainability concerns. Stakeholders identified gas flaring, oil spill incidents, ecosystem degradation, and air-quality deterioration as major consequences of weak petroleum revenue governance. The high mean scores recorded across governance challenge variables (overall mean = 3.92, SD = 0.99) demonstrate broad stakeholder consensus regarding the need for stronger transparency, accountability, and institutional oversight mechanisms.

The qualitative findings complemented the statistical results. Interview participants consistently emphasized inadequate transparency, weak accountability mechanisms, corruption, and limited public participation as key barriers to effective petroleum revenue management. These themes reinforce the quantitative evidence and demonstrate that governance deficiencies remain central obstacles to achieving sustainable development outcomes in Nigeria.

5. Discussion of Findings

The findings demonstrate that petroleum revenue governance plays a critical role in determining both economic stability and environmental sustainability in Nigeria. The regression results indicate that institutional quality significantly enhances GDP per capita growth ($\beta = 0.38$, $p < 0.01$), while transparency and accountability also exert positive effects on economic performance. These findings support the Resource Curse Theory, which argues that the developmental benefits of natural resource wealth depend largely on the quality of institutions responsible for managing resource revenues.

The descriptive statistics further revealed substantial petroleum revenue volatility (mean volatility index = 0.42), suggesting continued vulnerability of the Nigerian economy to fluctuations in international oil prices. This finding is consistent with Ogunjumo et al. (2024), who reported that oil revenue instability remains a major source of fiscal uncertainty in Nigeria. The positive relationship observed between weak governance and inflationary pressures also indicates that deficiencies in petroleum revenue management contribute to broader macroeconomic instability.

Environmental findings equally provide strong evidence that governance weaknesses extend beyond economic outcomes. Stakeholders identified gas flaring, oil spill incidents, ecosystem degradation, and air pollution as significant consequences of ineffective petroleum revenue governance. These findings support the growing literature on environmental governance, which emphasizes that transparency, accountability, and effective institutional oversight are necessary conditions for achieving sustainable resource management and environmental protection in resource-dependent economies.

In summary, the integrated analysis supported by the evidence presented in Figure 2, 3, and Table 4, 5 and 6, demonstrates that Nigeria's petroleum revenue management remains constrained by corruption, week institutional oversight, and insufficient stakeholder engagement. The results support the Resource Curse Theory by illustrating how resource abundance can exacerbate

institutional weaknesses and economic vulnerability. By addressing these challenges and leveraging the identified opportunities, policymakers and industry actors can transform Nigeria's oil wealth into a sustainable driver of economic growth and environmental stewardship.

5.1. Comparative case evidence

From Seifert et al. [11] study, we learn that Austrian sovereign wealth fund model protected the fiscal policy from volatility. Ghana's Petroleum Revenue Management Act allowed [6] to study an improvement in reporting standards.

Chen et al. [18] showed that Angola had the same governance problems as Nigeria. The evidence suggests that it is the quality of governance that determines development outcomes, not the quantity of resources available. The comparative international evidence presented in Table 5 suggests that governance quality remains a critical determinant of development outcomes across resource-dependent economies.

Practical and Managerial Implications

Governments could:

* Create and make available real-time public revenue dashboards
* Require the disclosure of beneficial ownership
* Create independent oversight bodies for the petroleum sector
* Use satellites for environmental monitoring

Industry players should implement ESG-compatible investment policies and adopt transparent reporting practices.

Table 5. Comparative international evidence.

Country	Governance Approach	Development Outcome
Norway	Sovereign Wealth Fund	Stable growth
Ghana	Petroleum Revenue Act	Improved transparency
Angola	Weak governance	Resource curse effects
Nigeria	Mixed governance outcomes	Environmental and fiscal challenges

Table 6. Regression results for the effects of petroleum revenue governance on economic performance.

Predictor Variable	GDP Growth (β)	t-value	p-value	Inflation (β)	t-value	p-value34
Transparency	0.13	4.12	0.000	-0.19	-2.43	0.016
Accountability	0.27	3.66	0.001	-0.15	-2.11	0.037
Institutional Quality	0.38	5.21	0.000	-0.27	-3.04	0.003
Constant	1.24	2.67	0.008	4.16	3.51	0.001

Source: Authors' Computation (2026).

Note: Dependent Variables = GDP Per Capita Growth and Inflation Rate; Model Statistics ; GDP Growth Model: $R2 = 0.48$, $F = 32.17$, $P < 0.001$; Inflation Model: $R2 = 0.35$, $F = 21.08$, $p < 0.001$

The regression analysis demonstrates that petroleum revenue governance significantly influences economic outcomes in Nigeria. Institutional quality emerged as the strongest predictor of GDP per capita growth ($\beta = 0.38$, $p < 0.01$), indicating that stronger governance systems contribute positively to economic performance. Transparency and accountability also exhibit positive effects on growth. Conversely, governance weaknesses contribute to inflationary pressures, suggesting that improvements in petroleum revenue management can enhance macroeconomic stability. The explanatory power of the models ($R^2 = 0.48$ and 0.35 respectively) indicates that governance variables account for a substantial proportion of variations in economic performance.

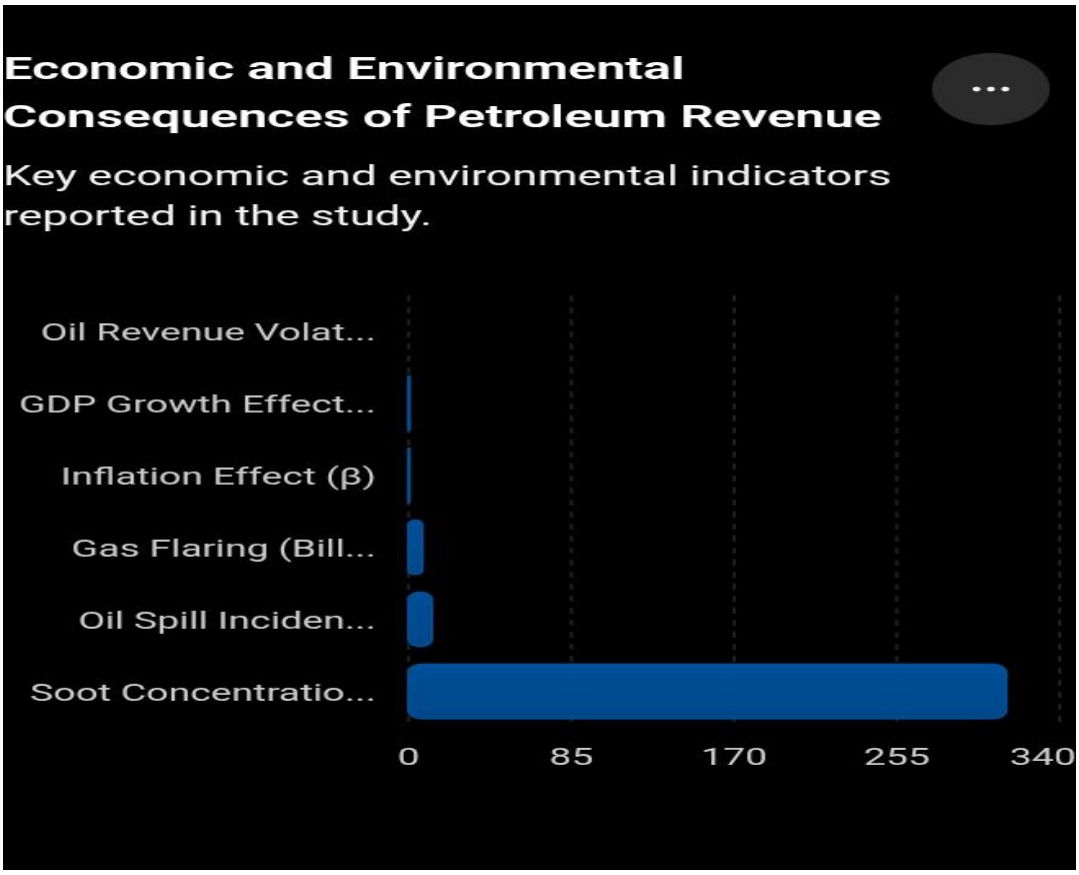

Figure 3. Stakeholder perceptions of economic and environmental consequences of petroleum revenue management.

The figure summarises stakeholders' perceptions [Figure 3] regarding the significant economic and environmental consequences of petroleum revenue management in Nigeria. Respondents identified revenue volatility, fiscal instability, gas flaring, oil spill incidents, ecosystem degradation, and air-quality concerns as significant challenges. These findings reinforce the need for stronger governance, transparency, and environmental accountability mechanisms.

5.2. Environmental outcomes

Secondary evidence from petroleum-sector monitoring reports indicates that gas flaring, crude oil spills, and greenhouse gas emissions remain major environmental concerns within Nigeria's petroleum-producing regions. Reports published by [19 & 20] consistently identify gas flaring and oil spill incidents as significant contributors to environmental degradation, biodiversity loss, and public health challenges in host communities. Furthermore, environmental monitoring studies conducted within the Niger Delta continue to report air-quality concerns associated with petroleum-related activities. These findings suggest that weaknesses in petroleum revenue governance have implications not only for economic performance but also for environmental sustainability and

community well-being.The stakeholder perceptions summarized in Figure 3 reinforce the quantitative findings regarding the economic and environmental consequences of weak petroleum revenue governance.

5.3. Economic outcomes

The findings indicate that stakeholders perceive petroleum revenue volatility as a significant source of macroeconomic uncertainty. Respondents highlighted that fluctuations in oil revenues adversely affect government budgeting, public expenditure planning, inflation control, and broader economic stability. Stakeholders also noted that excessive dependence on petroleum revenues has contributed to the underdevelopment of non-oil sectors, particularly manufacturing and agriculture, thereby reinforcing the structural characteristics commonly associated with resource-dependent economies.

5.4. Innovation statement

This paper has crafted three unique innovations:

1. Methodological Innovation: This is the first study to coalesce matters of governance, economics, and the environment with a convergence model of mixed methods.

2. Empirical Innovation: This is the first study to capture gas flaring, spill frequency, and the soot index in the same study of petroleum governance, and to analyse the volatility index and breakeven oil price.

3. Theoretical Innovation: This study extends the Resource Curse Theory to demonstrate the erosion of the environment as an institutional outcome of poorly managed petroleum revenue.

6. Conclusion and recommendations

The study clearly shows that the mismanagement of Nigeria's petroleum revenue contributes to the country's macros-economic instability and environmental issues. In the absence of adequate transparency, environmental monitoring, and fiscal stabilization policies to limit environmental/ economic interdependencies, Nigeria will continue to experience the resource curse. There is, however, potential to mitigate the challenges of the country's resource curse through the implementation of governance reforms aimed at converting the country's oil revenue into a resource for sustainable development.

Limitations and Future Research

a) The study is potentially subjective due to the reliance on the qualitative self-reported perceptions of the participants.

b) The environmental indicators were constrained to secondary data due to considerations of the measures.

c) The study's country focus was Nigeria, and as such, results may not be generalizable to the world.

Future research should expand both the empirical and methodological scope of petroleum revenue studies. Advanced statistical models, including structural equation modelling (SEM), panel regressions, and time-series econometrics, can quantify complex relationships between oil revenue governance, economic indicators, and environmental outcomes. Moreover, artificial intelligence-based approaches, such as supervised and unsupervised machine learning [8] and neural network modelling for energy and environmental efficiency [6], could be applied to predict the economic and ecological impacts of revenue management policies under different scenarios. Future studies could also explore regional and global comparative analyses, integrating environmental pollution indices, carbon emissions, and water and soil quality metrics to assess the sustainability of petroleum revenue management across diverse contexts. Finally,

1. To predict oil governance results, apply a machine-learning model such as a supervised vs. unsupervised model [21, 22].

2. Employ a neural network to enhanced modelling in an energy system to evaluate scenario(s) on energy efficiency [18].

3. A comparative study with other oil-producing countries in Africa will augment the insights of the research.

4. To assess real-time pollution, integrate environmental satellite monitoring, and other technologies of collaborative pollution.

Based on the findings of this study, the following recommendations are made to the government and policymakers for effective management of oil revenue in Nigeria:

i. Operationalize environmental monitoring with automated AI.

ii. Empirical prescriptions of the PIA that require real-time public orders on revenue streams.

iii. Practical measures of diversification to renewables for energy, and to close relations of economic diversification, are essential.

iv. Create petroleum revenue oversight body separate from government and industry.

By implementing these recommendations, Nigeria can improve the efficiency of petroleum revenue management, enhance transparency and accountability, and ensure that its oil wealth serves as a catalyst for sustainable economic growth and improved welfare.

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Conflicts of Interest: The authors declare no conflict of interest.

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