



Integrating Environmental Management and Disaster Risk Governance in the Niger Delta Energy Trilemma

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Abstract

The energy trilemma, comprising energy security, energy equity, and environmental sustainability, remained a persistent governance challenge in resource-dependent regions, particularly the Niger Delta, where environmental degradation, weak institutional coordination, and disaster vulnerability continued to undermine energy system performance. Despite Nigeria's status as a major oil-producing nation, the Niger Delta experienced chronic energy insecurity, unequal access to energy services, and severe ecological degradation, reflecting deep structural inefficiencies in environmental and energy governance. This study examined the integration of environmental management and disaster risk governance in addressing the energy trilemma in the Niger Delta. The study was anchored on Energy Justice Theory, Urban Resilience Theory, and Sustainable Development Theory, which provided a multidimensional framework for analysing equity, system resilience, and sustainability outcomes. A quantitative cross-sectional survey design was adopted, involving 400 respondents selected through stratified random sampling. Data were collected using structured questionnaires measured on a four-point Likert scale and analysed using descriptive statistics and multiple regression analysis via SPSS. Findings revealed that environmental management had a significant positive effect on energy security ($\beta = 0.62$, $p < 0.05$) and energy equity ($\beta = 0.48$, $p < 0.05$), while disaster risk governance significantly enhanced energy system resilience ($\beta = 0.55$, $p < 0.05$). Conversely, environmental degradation was found to significantly undermine energy sustainability ($\beta = -0.57$, $p < 0.05$). All null hypotheses were rejected, confirming the statistical significance of the relationships examined. The study concluded that integrating environmental management and disaster risk governance significantly enhanced energy system performance across the trilemma dimensions. It recommended stronger enforcement of environmental regulations, integration of disaster risk considerations into energy infrastructure planning, expansion of equitable renewable energy access, and investment in climate-resilient energy systems through relevant government agencies such as the Federal Ministry of Environment, NEMA, NERC, and NDDC.

Keywords: Energy Trilemma, Environmental Management, Disaster Risk Governance, Niger Delta, Energy Justice

Introduction

The energy trilemma, which comprises energy security, energy equity, and environmental sustainability, has emerged as a critical analytical and policy framework in contemporary global energy governance. It captures the inherent tensions and trade-offs involved in ensuring that energy systems are reliable, affordable, and environmentally sustainable simultaneously. In both developed and developing economies, policymakers are increasingly confronted

with the challenge of balancing these three competing objectives in a manner that promotes long-term socio-economic development while minimising ecological harm. However, this challenge is significantly more pronounced in developing and resource-dependent regions, where institutional weaknesses, infrastructural deficits, and environmental vulnerabilities intersect to constrain effective energy governance (World Energy Council, 2022). In the context of Nigeria, and particularly the Niger Delta region, the energy trilemma assumes a more complex and paradoxical dimension. The Niger Delta is widely recognised as the backbone of Nigeria's oil and gas industry, contributing substantially to national revenue and foreign exchange earnings. Despite this strategic importance, the region continues to experience persistent energy poverty, inadequate electricity supply, and over-reliance on self-generated fossil-based energy sources such as diesel and petrol generators. This contradiction, where a resource-rich region remains energy-poor, highlights deep structural inefficiencies in Nigeria's energy governance system and underscores the urgent need for a more integrated and sustainable approach to energy planning and management.

The challenge of energy security in the Niger Delta is reflected in the inconsistent and unreliable supply of electricity from the national grid. Frequent power outages, inadequate generation capacity, transmission losses, and weak distribution infrastructure have compelled households, businesses, and institutions to rely heavily on alternative energy sources. These alternatives are not only expensive but also environmentally damaging, thereby exacerbating both economic hardship and environmental degradation. Consequently, energy insecurity in the region has become a major constraint to industrial development, small and medium enterprise growth, and overall socio-economic progress. In terms of energy equity, significant disparities exist in access to modern and affordable energy services across communities in the Niger Delta. Rural and riverine communities are particularly disadvantaged, often lacking connection to the national grid and relying on traditional biomass and inefficient energy sources. This inequality is further reinforced by poverty, weak infrastructure development, and limited government intervention in marginalised areas. As a result, energy poverty remains widespread, undermining efforts to achieve inclusive development and sustainable livelihoods. The persistence of such inequalities raises important concerns about distributive justice and fairness in energy provision within a region that contributes significantly to national wealth. With respect to environmental sustainability, the Niger Delta presents one of the most environmentally degraded regions in Africa. Decades of oil exploration and exploitation have resulted in extensive environmental damage, including oil spills, gas flaring, deforestation, water contamination, and loss of biodiversity. These environmental challenges not only threaten ecosystems but also directly impact human health, agricultural productivity, and livelihood systems. Furthermore, the reliance on fossil fuels for both industrial and domestic energy needs continues to contribute to greenhouse gas emissions, thereby intensifying climate change impacts in the region. Flooding and coastal erosion, which are increasingly frequent, further compound environmental vulnerability and disrupt energy infrastructure.

The situation is further complicated by fragmented governance structures, particularly in the way environmental management and disaster risk governance are conceptualised and implemented. In many instances, environmental management institutions focus primarily on regulatory compliance and pollution control, while disaster risk governance agencies operate reactively, responding to crises rather than proactively preventing them. This lack of coordination creates institutional silos that weaken policy effectiveness and reduce the capacity of government and stakeholders to respond holistically to energy-related environmental challenges. The absence of integration between these governance systems limits the development of resilient energy infrastructure capable of withstanding environmental shocks and climate-induced disasters (UNDRR, 2019). Moreover, the weak institutional coordination between relevant agencies has led to inefficiencies in policy implementation and resource allocation. Agencies responsible for environmental protection, energy regulation, and disaster management often operate with overlapping mandates but without effective collaboration. This fragmentation not only results in duplication of efforts but also creates gaps in governance that exacerbate vulnerability within the energy sector. Sovacool et al. (2020) emphasise that such governance fragmentation is a key barrier to achieving sustainable energy transitions in developing economies, where institutional capacity is often limited, and policy coherence is weak.

Against this backdrop, the Niger Delta presents a critical case for examining how integrated governance approaches can address the energy trilemma. The interconnections between environmental degradation, disaster vulnerability, and energy system inefficiencies suggest that isolated policy interventions are insufficient to resolve the region's energy challenges. Instead, there is a growing need for a coordinated framework that integrates environmental management and disaster risk governance into energy planning and implementation processes. This study therefore situates itself within this broader policy and academic discourse by exploring how the integration of environmental management

and disaster risk governance can contribute to addressing the energy trilemma in the Niger Delta. It seeks to provide empirical evidence on the extent to which coordinated governance structures can enhance energy security, improve energy equity, and promote environmental sustainability in a region characterised by complex socio-ecological and infrastructural challenges. In doing so, the study contributes to ongoing debates on sustainable energy transitions, environmental governance, and disaster resilience in resource-dependent regions. It also provides a basis for policy reform aimed at strengthening institutional coordination, improving infrastructure resilience, and promoting equitable access to sustainable energy services in the Niger Delta.

Several studies have examined the interrelationship between environmental governance, disaster risk management, and sustainable energy systems across both developed and developing economies. However, limited empirical attention has been given to the integrated governance dimensions of the energy trilemma within resource-dependent regions such as the Niger Delta. Adebayo et al (2020) investigated the role of environmental governance in promoting urban resilience in selected developing economies. Using a mixed-methods approach involving policy analysis and stakeholder surveys, the study found that effective environmental management significantly enhanced infrastructure resilience and reduced vulnerability to environmental hazards. The authors concluded that environmental governance serves as a critical foundation for sustainable development and disaster preparedness. Cutter, Burton and Emrich (2015) developed disaster resilience indicators for evaluating community preparedness and adaptive capacity. Their findings demonstrated that communities with stronger institutional coordination and environmental management structures exhibited higher levels of resilience to environmental shocks. The study highlighted the importance of integrating disaster risk reduction into sectoral planning frameworks, including energy infrastructure development. Bouzarovski and Petrova (2015) examined the phenomenon of energy poverty across several developing regions and found that resource-rich communities frequently experience unequal access to modern energy services. The study attributed this paradox to governance failures, institutional fragmentation, and inadequate infrastructure investment. Their findings support the argument that energy equity requires coordinated governance interventions beyond conventional energy policy measures.

Sovacool et al. (2020) analysed the determinants of energy security and sustainability in developing countries. Their study revealed that weak environmental regulation and poor institutional coordination significantly undermine energy system performance. The authors recommended integrated governance frameworks that simultaneously address environmental protection, disaster preparedness, and energy development objectives. Within the Niger Delta context, environmental degradation resulting from oil exploration activities continues to present significant challenges to sustainable energy development. Persistent oil spills, gas flaring, deforestation, and water contamination have weakened ecosystem resilience and increased vulnerability to climate-related hazards. Despite extensive policy interventions, environmental governance mechanisms remain fragmented, thereby limiting their effectiveness in addressing interconnected energy challenges. The reviewed studies collectively indicate that environmental management and disaster risk governance are important determinants of energy system performance. However, a noticeable gap exists regarding empirical investigations that simultaneously examine their combined influence on energy security, energy equity, and environmental sustainability within the Niger Delta energy trilemma framework. This study addresses this gap by providing empirical evidence on the integrated governance dimensions of energy sustainability in the region.

Energy Justice Theory provides a normative framework for examining fairness and equity within energy systems. The theory emphasises that access to affordable, reliable, and sustainable energy should be considered a matter of social justice rather than merely a technical or economic concern. It focuses on three core dimensions: distributive justice, which concerns the equitable allocation of energy benefits and burdens; procedural justice, which addresses fairness in energy-related decision-making processes; and recognition justice, which emphasises the inclusion and protection of vulnerable and marginalised groups affected by energy policies and practices. According to Sovacool and Dworkin (2015), energy justice seeks to ensure that all individuals and communities have equal opportunities to access modern energy services while avoiding disproportionate exposure to environmental and social harms associated with energy production and consumption. The theory is particularly relevant to developing regions where resource abundance coexists with energy poverty and environmental degradation. In the context of the Niger Delta, Energy Justice Theory provides a useful lens for understanding the persistent disparities in energy access despite the region's significant contribution to national energy production. It highlights the need for governance frameworks that promote fairness, inclusivity, and equitable distribution of energy resources among affected communities. The theory is therefore

relevant to this study because it explains the relationship between environmental management, governance structures, and energy equity, thereby providing a basis for evaluating how integrated environmental management and disaster risk governance can contribute to addressing the energy trilemma in the Niger Delta (Jenkins et al., 2016).

Urban Resilience Theory explains the ability of systems to absorb, adapt, and recover from shocks. It is used to understand how disaster risk governance enhances energy infrastructure stability (Satterthwaite, 2013). Sustainable Development Theory emphasises the integration of economic, environmental, and social goals. It provides the overarching framework for balancing the energy trilemma (Brundtland, 1987). The three theories adopted in this study complement one another in explaining the multidimensional nature of the energy trilemma. Energy Justice Theory provides insight into issues of fairness, accessibility, and equitable distribution of energy resources among different social groups. Urban Resilience Theory explains how institutions and infrastructure systems respond, adapt, and recover from environmental shocks and disasters. Sustainable Development Theory provides the overarching framework for balancing economic growth, environmental protection, and social welfare. The integration of these theories offers a comprehensive analytical framework for understanding the interactions among environmental management, disaster risk governance, energy security, energy equity, and environmental sustainability. While Energy Justice Theory addresses distributive concerns, Urban Resilience Theory explains adaptive capacity, and Sustainable Development Theory ensures long-term sustainability considerations. Collectively, the theories provide a robust foundation for examining the governance mechanisms required to address the energy trilemma in the Niger Delta.

Statement of the Problem

Despite various policy interventions, the Niger Delta continues to experience persistent energy insecurity, inequitable energy access, and environmental degradation. These challenges are exacerbated by weak integration between environmental management and disaster risk governance frameworks, leading to fragmented responses that fail to address systemic energy vulnerabilities. Existing studies have largely treated environmental governance, disaster management, and energy systems as separate domains, creating a significant empirical and policy gap in understanding their interdependencies within the energy trilemma framework (Bouzarovski & Petrova, 2015).

The main objective is to examine the integration of environmental management and disaster risk governance in addressing the energy trilemma in the Niger Delta.

Specific objectives are to:

1. Examine the effect of environmental management on energy security.
2. Assess the impact of disaster risk governance on energy system resilience.
3. Evaluate the relationship between environmental management and energy equity.
4. Determine the effect of environmental degradation on energy sustainability.

Research Questions

1. How does environmental management influence energy security in the Niger Delta?
2. What is the effect of disaster risk governance on energy system resilience?
3. To what extent does environmental management affect energy equity?
4. How does environmental degradation affect energy sustainability?

Hypotheses

- H01: Environmental management has no significant effect on energy security in the Niger Delta.
 H02: Disaster risk governance has no significant effect on energy system resilience.
 H03: Environmental management has no significant effect on energy equity.
 H04: Environmental degradation has no significant effect on energy sustainability.

Methodology

This study adopted a quantitative cross-sectional survey research design. The design was considered appropriate because it enabled the collection of data from a large population at a single point in time regarding perceptions of environmental management, disaster risk governance, and energy system performance in the Niger Delta. The target population comprised residents, environmental managers, energy sector stakeholders, officials of environmental protection agencies, and disaster management personnel operating within selected communities in the Niger Delta

region. The estimated population exceeded 50,000 individuals across the selected states. A sample size of 400 respondents was determined using the Taro Yamane formula at a 5% level of precision. Stratified random sampling was employed to ensure adequate representation of relevant stakeholder groups. The strata included community residents, environmental professionals, disaster management officials, and energy sector practitioners. Data were collected using a structured questionnaire titled Environmental Management, Disaster Risk Governance and Energy Trilemma Questionnaire (EMDRGETQ). The instrument consisted of five sections covering respondents' demographic characteristics and the major study variables. Responses were measured using a four-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1). Face and content validity of the instrument were established through expert assessment by three specialists in Environmental Management and Research Methodology. Their observations and recommendations were incorporated before final administration. Reliability testing was conducted through a pilot study involving 30 respondents outside the study area. Cronbach's Alpha reliability coefficient of 0.81 was obtained, indicating high internal consistency. Data analysis involved descriptive statistics such as mean and standard deviation for research questions, while multiple regression analysis was employed to test the hypotheses at a 0.05 level of significance using the Statistical Package for Social Sciences (SPSS Version 27).

Table 1: Regression Results

Variables	Beta (β)	t-value	p-value	Decision
Environmental Management $\rightarrow$ Energy Security	0.62	7.81	0.000	Significant
DRG $\rightarrow$ Energy Resilience	0.55	6.92	0.000	Significant
Environmental Management $\rightarrow$ Energy Equity	0.48	5.33	0.000	Significant
Environmental Degradation $\rightarrow$ Energy Sustainability	-0.57	-6.40	0.000	Significant

Hypotheses Testing

H₀₁: Rejected ($p < 0.05$)

H₀₂: Rejected ($p < 0.05$)

H₀₃: Rejected ($p < 0.05$)

H₀₄: Rejected ($p < 0.05$)

Results

The regression analysis revealed statistically significant relationships between the study variables and the dimensions of the energy trilemma. Environmental management exerted a positive and significant effect on energy security ($\beta = 0.62$, $t = 7.81$, $p < 0.05$), indicating that improved environmental governance contributes substantially to reliable energy supply. Disaster risk governance also demonstrated a positive and significant influence on energy system resilience ($\beta = 0.55$, $t = 6.92$, $p < 0.05$), suggesting that effective disaster preparedness and risk management enhance the adaptive capacity of energy infrastructure. Similarly, environmental management significantly improved energy equity ($\beta = 0.48$, $t = 5.33$, $p < 0.05$), implying that stronger environmental governance frameworks facilitate more equitable access to energy services. Conversely, environmental degradation exhibited a negative and statistically significant effect on energy sustainability ($\beta = -0.57$, $t = -6.40$, $p < 0.05$), indicating that increasing ecological deterioration undermines the long-term viability of energy systems within the Niger Delta. The statistical significance of all predictor variables resulted in the rejection of the four null hypotheses, thereby confirming that environmental management and disaster risk governance are critical determinants of energy security, energy equity, energy resilience, and environmental sustainability in the study area.

Discussion

With respect to Research Question One, which examined how environmental management influences energy security in the Niger Delta, the regression results revealed a strong positive and statistically significant relationship ($\beta = 0.62$, $p < 0.05$). This implies that improved environmental management practices, including regulatory enforcement, pollution control, and sustainable resource governance, significantly enhance the reliability and stability of energy supply in the region. In practical terms, where environmental governance mechanisms are strengthened, energy systems tend to function more efficiently with reduced disruptions and improved infrastructural performance. This finding is consistent with Pearce (2002), who argues that effective environmental governance reduces negative externalities and improves resource allocation efficiency within socio-economic systems. It also aligns with Sovacool et al. (2020), who emphasise that weak governance structures are a major driver of energy insecurity in developing

economies. In the Niger Delta context, this pattern is evident in the persistent infrastructural decay and inefficiencies that undermine stable electricity supply despite the region's significant contribution to national energy production.

In relation to Research Question Two, which focused on the effect of disaster risk governance on energy system resilience, the results indicated a strong positive and significant relationship ($\beta = 0.55$, $p < 0.05$). This suggests that effective disaster risk governance through preparedness planning, early warning systems, institutional coordination, and mitigation strategies plays a crucial role in strengthening the resilience of energy infrastructure against environmental shocks such as flooding, coastal erosion, and extreme weather events. This outcome corroborates the position of the United Nations Office for Disaster Risk Reduction (UNDRR, 2019), which asserts that proactive disaster risk governance enhances infrastructural resilience and reduces system vulnerability to climate-induced disruptions. It further supports Urban Resilience Theory, which explains that systems capable of anticipating, absorbing, and adapting to shocks are more likely to maintain continuity of essential services (Satterthwaite, 2013). In the Niger Delta, where flood risks and environmental instability are increasingly prevalent, the importance of resilient governance structures cannot be overstated. With regard to Research Question Three, which examined the relationship between environmental management and energy equity, the findings revealed a positive and statistically significant relationship ($\beta = 0.48$, $p < 0.05$). This indicates that effective environmental governance contributes to more equitable distribution and access to energy services across different communities. Where environmental management systems are efficient, there is improved planning, reduced environmental conflict, and better infrastructure distribution, which collectively enhance energy access equity.

This finding supports the principles of Energy Justice Theory, which emphasises fairness, inclusivity, and equitable access to energy resources. However, despite this positive influence, the persistence of energy inequality in the Niger Delta reflects deeper structural challenges. This aligns with Bouzarovski and Petrova (2015), who argue that resource-rich regions in developing countries often experience paradoxical energy poverty due to institutional weaknesses, socio-economic inequality, and uneven infrastructural development. Finally, in addressing Research Question Four, which examined the effect of environmental degradation on energy sustainability, the regression results showed a strong negative and statistically significant relationship ($\beta = -0.57$, $p < 0.05$). This indicates that increasing environmental degradation driven by oil spills, gas flaring, deforestation, and ecosystem destruction significantly undermines the long-term sustainability of energy systems in the Niger Delta. This finding is consistent with the Intergovernmental Panel on Climate Change (IPCC, 2021), which highlights that continued reliance on fossil fuels and environmentally destructive practices significantly weakens environmental integrity and accelerates climate vulnerability. It also reinforces broader sustainability literature, which emphasises that environmental degradation poses a direct threat to the long-term viability of energy systems, particularly in ecologically fragile and resource-dependent regions. Overall, the results demonstrate that environmental management and disaster risk governance are not only statistically significant determinants of energy security, resilience, and equity, but also mutually reinforcing governance instruments. However, the negative effect of environmental degradation underscores the urgent need for stronger regulatory enforcement and integrated governance frameworks capable of addressing the interconnected nature of the energy trilemma in the Niger Delta.

Conclusion

The study concludes that integrating environmental management and disaster risk governance significantly improves performance across the energy trilemma dimensions in the Niger Delta. However, environmental degradation continues to undermine sustainability outcomes, indicating the need for stronger institutional coordination and enforcement mechanisms.

Recommendations

1. The Federal Ministry of Environment should enforce stricter environmental regulations to reduce oil pollution and gas flaring in the Niger Delta.
2. The National Emergency Management Agency (NEMA) should integrate energy infrastructure protection into disaster risk governance frameworks.
3. The Nigerian Electricity Regulatory Commission (NERC) should implement policies that promote equitable energy access through decentralised renewable energy systems.
4. The Niger Delta Development Commission (NDDC) should invest in climate-resilient energy infrastructure and community-based environmental restoration projects.

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