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Qualitative and Quantitative Evaluation of Decarbonization and Climate Resilience Strategies in Nigeria's Energy Sector

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Abstract

Nigeria's energy sector constitutes a dual nexus of climate vulnerability and emissions intensity, driven predominantly by fossil fuel dependence, infrastructure deficits, and rapidly increasing energy demand. This study presents a systematic assessment of federal-level climate change mitigation and adaptation strategies within the sector, with emphasis on key policy instruments, including the Energy Transition Plan (ETP), Renewable Energy Master Plan (REMP), National Adaptation Strategy and Plan of Action on Climate Change (NASPA-CCN), and the National Adaptation Plan (NAP). A qualitative, policy-oriented analytical framework was adopted, integrating structured narrative review with comparative policy benchmarking against international climate governance frameworks. The analysis evaluates the coherence, technical robustness, and implementation efficacy of these policies using criteria such as decarbonization potential, institutional capacity, financing mechanisms, and monitoring and evaluation (M&E) architecture. Results indicate that while the ETP and REMF articulate ambitious decarbonization trajectories—particularly in renewable energy penetration, gas-to-power transition, and energy efficiency optimization—their operationalization is constrained by capital scarcity, grid instability, technological gaps, and weak regulatory enforcement. Conversely, adaptation frameworks (NASPA-CCN and NAP) provide broad-based resilience strategies targeting climate-sensitive energy infrastructure; however, they exhibit limited granularity in risk quantification, inadequate integration at subnational levels, and underdeveloped performance tracking systems. Despite strong alignment with global commitments, including the Paris Agreement and the Sustainable Development Goals (SDGs), systemic barriers—spanning financial, technical, and institutional domains—continue to impede effective policy translation into measurable outcomes. The study concludes that enhancing policy effectiveness requires the deployment of innovative financing models, strengthening of institutional governance structures, integration of data-driven decision-support systems, and inclusive stakeholder participation to achieve a resilient and low-carbon energy transition in Nigeria.

Keywords

Climate Change, Energy Sector, Mitigation, Adaptation, Nigeria, Policy Assessment

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1. Introduction

Climate change is one of the most pressing challenges of the 21st century, with profound implications for ecosystems, economies, and societies worldwide. The Intergovernmental Panel on Climate Change (IPCC) has consistently highlighted the urgent need to address both mitigation—reducing greenhouse gas (GHG) emissions—and adaptation—enhancing resilience to climate impacts (IPCC, 2021). The energy sector is central to these efforts because it is both the primary contributor to global emissions and a critical enabler of socio-economic development. Globally, energy-related activities account for nearly three-quarters of GHG emissions, underscoring the sector's pivotal role in climate action (IEA, 2022).

Nigeria, Africa's most populous country and largest economy, faces a unique dilemma. On one hand, the country is endowed with abundant fossil fuel resources, which form the backbone of its economy, contributing over 80% of export earnings and about 50% of government revenue (World Bank, 2022). On the other hand, this dependence on oil and natural gas has entrenched high emissions, environmental degradation, and economic vulnerability to global energy transitions (Onigbinde, 2021). Moreover, Nigeria's energy infrastructure is underdeveloped, with an estimated 85 million people lacking access to electricity and many households still reliant on biomass for cooking (IEA, 2021). This dual reality highlights the need for policies that balance economic growth with climate resilience.

The impacts of climate change are already evident across Nigeria. Rising temperatures, erratic rainfall, and extreme weather events

such as droughts and flooding threaten energy production and distribution systems (Nwoko et al., 2020). Hydropower plants, which contribute a significant share of electricity, are increasingly affected by reduced water levels due to prolonged dry spells. Oil and gas infrastructure in the Niger Delta faces growing risks from sea-level rise, coastal erosion, and flooding (Adenle, 2020). These vulnerabilities underscore the urgent need for adaptation strategies in the sector, particularly given Nigeria's high exposure and low adaptive capacity.

To address these challenges, Nigeria has developed several policy instruments at the federal level. The Energy Transition Plan (ETP) outlines the pathway to achieving net-zero emissions by 2060, with renewable energy and natural gas as central components. The Renewable Energy Master Plan (REMP) sets targets for increasing the share of renewables in the energy mix, particularly solar, hydro, and biomass. The National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN) and the National Adaptation Plan (NAP) emphasize resilience-building measures, community-based adaptation, and ecosystem protection (Federal Ministry of Environment, 2011; 2021). Collectively, these policies reflect Nigeria's efforts to align with global frameworks such as the Paris Agreement and the Sustainable Development Goals (SDGs).

However, the effectiveness of these strategies has been uneven. Studies have noted significant barriers, including inadequate financing, weak governance, limited technical expertise, and low public awareness (Abubakar & Aina, 2019; Effiong et al., 2024). For instance, despite abundant solar potential,

renewable energy deployment remains below 5% of the national energy mix, largely due to high costs and lack of enabling infrastructure (Ajayi et al., 2022). Similarly, adaptation strategies often remain at the policy level with limited implementation at the community scale (Butu et al., 2022).

Given these challenges, assessing Nigeria's mitigation and adaptation strategies at the federal level is critical for identifying gaps, highlighting opportunities, and ensuring that the energy sector contributes effectively to national and global climate goals. This paper focuses on evaluating the strengths and weaknesses of these strategies, providing evidence-based insights to inform future energy and climate policy.

2. Literature Review

2.1 Climate Change and the Energy Sector

The energy sector is central to global climate change debates, as it accounts for nearly 75% of greenhouse gas (GHG) emissions worldwide (IEA, 2022). In developing countries like Nigeria, the sector poses a dual challenge: it is both a major source of emissions and highly vulnerable to climate impacts, including temperature extremes, flooding, and drought (Nwoko et al., 2020). Hydropower facilities, for example, are increasingly affected by reduced water inflows, while oil and gas installations in the Niger Delta face heightened risks from sea-level rise and coastal erosion (Adenle, 2020). These vulnerabilities highlight the need for strong mitigation and adaptation strategies in the sector.

2.2 Mitigation Strategies in Nigeria's Energy Sector

Mitigation involves reducing emissions through cleaner energy systems, improved efficiency,

and sustainable land management (IPCC, 2021). Nigeria's Energy Transition Plan (ETP), launched in 2022, provides a roadmap for achieving net-zero emissions by 2060. The plan emphasizes renewable energy, particularly solar, and natural gas as a "transition fuel" (Federal Government of Nigeria, 2022). Similarly, the Renewable Energy Master Plan (REMP) sets targets for scaling up renewables in electricity generation, expanding rural access, and reducing environmental degradation (Energy Commission of Nigeria, 2005; updated 2022).

Scholars argue, however, that these plans face barriers such as high investment costs, policy inconsistency, and low public awareness (Ajayi et al., 2022; Abubakar & Aina, 2019). Despite Nigeria's vast solar potential, renewable penetration remains below 5% of the energy mix, with diesel and petrol generators still widely used (IEA, 2021). Furthermore, inadequate financing facilities and weak institutional capacity limit progress (Effiong et al., 2024).

2.3 Adaptation Strategies in Nigeria's Energy Sector

Adaptation strategies focus on enhancing resilience to climate impacts already occurring or anticipated. Nigeria has introduced several adaptation frameworks, including the National Adaptation Strategy and Plan of Action on Climate Change (NASPA-CCN) (2011) and the **National Adaptation Plan (NAP)** (2021). These documents emphasize community-based adaptation, ecosystem resilience, and gender-responsive approaches (Federal Ministry of Environment, 2011; 2021).

However, studies show that adaptation in Nigeria's energy sector is often poorly implemented. Butu et al. (2022) argue that adaptation policies remain largely at the

national level with limited translation into local action. Similarly, community-level awareness and engagement remain weak, limiting the success of adaptation initiatives (Ayanlade et al., 2022). In practice, most adaptation measures are fragmented and driven by donor-funded projects rather than coherent national strategies (Edeh et al., 2023).

2.4 Challenges in Implementing Mitigation and Adaptation

Several barriers affect the effectiveness of climate strategies in Nigeria's energy sector. Financial constraints remain the most significant, as renewable energy projects often require high upfront costs and face difficulties in accessing credit (Ngumah et al., 2013). Institutional inefficiencies, weak governance, and policy inconsistency further undermine implementation (Abubakar & Aina, 2019). Technical limitations, such as a shortage of skilled manpower for renewable energy maintenance, also hinder progress (Abdelrazik et al., 2022).

Social challenges include low awareness of renewable energy options among rural communities and resistance to change stemming from reliance on cheap but polluting energy sources such as kerosene and biomass (Usman et al., 2015). Collectively, these barriers explain why Nigeria continues to struggle with low renewable penetration despite ambitious policies.

2.5 Research Gaps

While Nigeria has developed multiple mitigation and adaptation frameworks, there is limited empirical research on their effectiveness in the energy sector. Much of the literature highlights policy intentions rather than actual outcomes. There is also a lack of integrated studies that examine how mitigation and adaptation strategies can be

harmonized for greater impact. This gap underscores the importance of critically assessing existing federal-level strategies, which is the focus of this study.

3. Methodology

3.1 Research Design

This study adopted a qualitative narrative review design to assess climate change mitigation and adaptation strategies in Nigeria's energy sector at the federal level. A narrative review is appropriate because it enables the synthesis of diverse policy documents, academic literature, and institutional reports to generate a holistic understanding of complex policy frameworks (Snyder, 2019).

3.2 Data Sources

The analysis relied on secondary data collected from multiple reputable sources:

- a. **Government Policy Documents:** Nigeria's *Energy Transition Plan* (2022), *Renewable Energy Master Plan* (2005, updated 2022), *National Adaptation Strategy and Plan of Action on Climate Change* (NASPA-CCN, 2011), and *National Adaptation Plan* (2021).
- b. **International Reports:** Publications by the Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA), and United Nations Development Programme (UNDP) related to climate change and energy transition.
- c. **Peer-reviewed Literature:** Academic studies on mitigation and adaptation in Nigeria's energy sector retrieved from databases such as Scopus, Web of Science, and Google Scholar.

3.3 Inclusion and Exclusion Criteria

Documents and literature were included if they:

1. Focused on climate change mitigation or adaptation strategies in Nigeria's energy sector.
2. Were published between 2010 and 2024.
3. Provided empirical or policy-relevant insights at the federal/national level.

Exclusion criteria included:

- a. Non-peer-reviewed opinion pieces, blogs, or commentaries.
- b. Studies not directly addressing Nigeria's energy sector or climate policies.
- c. Outdated publications before 2010, except when historically significant.

3.4 Data Collection Procedure

Policy documents were accessed from official government websites (e.g., Federal Ministry of Environment, Energy Commission of Nigeria), while academic literature was retrieved using search terms such as "climate change mitigation Nigeria energy", "adaptation strategies Nigeria energy sector", and "renewable energy policy Nigeria." Reference chaining was also used to identify additional relevant works cited in the reviewed literature.

3.5 Data Analysis A thematic content analysis was conducted. The data were coded into categories reflecting:

1. Mitigation strategies (e.g., renewable energy expansion, energy efficiency policies, gas transition).

2. Adaptation strategies (e.g., community-based resilience, infrastructure protection, policy integration).
3. Strengths and weaknesses of existing frameworks.
4. Alignment with international commitments (e.g., Paris Agreement, SDGs, Nigeria's NDCs).

This process enabled the identification of common patterns, policy gaps, and emerging opportunities.

3.6 Ethical Considerations

All sources were properly cited to maintain academic integrity. Only publicly available documents and peer-reviewed studies were used, ensuring compliance with ethical standards for secondary data research.

3. Results and Discussion

3.1 Overview of Federal Mitigation and Adaptation Strategies

Nigeria has developed several policy instruments to address climate change in the energy sector. These include the Energy Transition Plan (ETP, 2022), the Renewable Energy Master Plan (REMP, 2005; updated 2022), the National Adaptation Strategy and Plan of Action on Climate Change (NASPA-CCN, 2011), and the National Adaptation Plan (NAP, 2021). Each framework contributes to Nigeria's commitments under the Paris Agreement and the Sustainable Development Goals (SDGs).

Table 1 summarizes the objectives, strengths, and challenges of these policies.

Table 1: Federal Mitigation and Adaptation Strategies in Nigeria's Energy Sector

Policy/Framework	Objectives	Strengths	Challenges/Weaknesses
Energy Transition Plan (ETP, 2022)	Achieve net-zero emissions by 2060; expand renewable energy; use natural gas as a transition fuel	Aligns with the Paris Agreement, ambitious targets, and a focus on just transition	Limited financing, weak data availability, and low institutional capacity
Renewable Energy Master Plan (REMP, 2005; updated 2022)	Scale up renewables (solar, hydro, biomass), improve rural electrification, and reduce environmental degradation	Provides clear roadmaps and targets; potential to enhance rural access and jobs	Policy inconsistency, inadequate funding, low awareness, and a shortage of skilled manpower
National Adaptation Strategy and Plan of Action on Climate Change (NASPA-CCN, 2011)	Promote community-based and ecosystem-based adaptation, and integrate climate resilience into national planning	Early recognition of adaptation needs, and inclusion of vulnerable groups	Poor implementation, weak monitoring and evaluation, and fragmented institutional coordination
National Adaptation Plan (NAP, 2021)	Mainstream adaptation into development planning enhances risk reduction and resilience, and a gender-responsive approach	Coherent with the Cancun Adaptation Framework, emphasis on cross-sectoral planning	Limited local-level translation, weak stakeholder engagement, and dependence on donor funding

3.2 Mitigation Strategies

The ETP and REMP outline Nigeria's vision for decarbonizing its energy sector. The ETP sets ambitious goals for renewable energy deployment and the gradual phasing out of fossil fuel dependence. The REMP, on the other hand, emphasizes the integration of renewable technologies into the energy mix. Despite these strengths, both policies face significant barriers. For instance, renewable penetration remains below 5% of the national electricity supply due to high initial investment

costs, market distortions, and weak regulatory enforcement (Ajayi et al., 2022; IEA, 2021).

3.3 Adaptation Strategies

Adaptation frameworks such as NASPA-CCN and the NAP highlight Nigeria's vulnerability to climate impacts and propose resilience-building measures. These include ecosystem restoration, community-based adaptation, and gender-responsive policies (Federal Ministry of Environment, 2011; 2021). However, most strategies remain at the policy level with

limited translation into actionable projects. Butu et al. (2022) note that adaptation efforts are fragmented, poorly monitored, and often reliant on international donor support rather than domestic financing.

3.4 Comparative Insights

Comparative evidence from other African countries underscores Nigeria's implementation gap. For example, South Africa has successfully integrated renewable energy auctions to attract private-sector investment, while Kenya's community-based adaptation programs have improved local resilience (AfDB, 2022). Nigeria could learn from these models by strengthening governance, incentivizing private-sector participation, and embedding adaptation strategies at the community level.

3.5 Synthesis of Findings

The analysis reveals a policy environment rich in ambition but weak in execution. Mitigation strategies are hindered by financial, technical, and institutional barriers, while adaptation measures lack local ownership and effective implementation. Strengthening climate governance, mobilizing sustainable finance, and enhancing community engagement are critical for closing these gaps.

4.0 Conclusion and Recommendations

This study assessed Nigeria's federal-level climate change mitigation and adaptation strategies in the energy sector. The findings reveal that Nigeria has developed several ambitious policies, including the *Energy Transition Plan (ETP)*, *Renewable Energy Master Plan (REMP)*, *National Adaptation Strategy and Plan of Action (NASPA-CCN)*, and the *National Adaptation Plan (NAP)*. Collectively, these frameworks demonstrate

Nigeria's commitment to global climate agreements such as the Paris Agreement and the Sustainable Development Goals.

However, the study shows that policy ambition is not matched by effective implementation. Mitigation strategies, though comprehensive, are hindered by inadequate financing, institutional weaknesses, policy inconsistency, and limited renewable energy penetration. Adaptation strategies, while emphasizing community resilience and ecosystem restoration, remain poorly executed and insufficiently integrated into local development planning. The overall picture is one of a strong policy foundation but limited operational success.

To strengthen Nigeria's mitigation and adaptation strategies in the energy sector, the following recommendations are proposed:

1. **Enhance Climate Finance:** The federal government should prioritize mobilizing domestic and international finance for renewable energy deployment and adaptation initiatives. This includes leveraging mechanisms such as the Green Climate Fund and public-private partnerships.
2. **Strengthen Institutional Capacity:** Improved governance structures, stronger inter-agency coordination, and effective monitoring and evaluation frameworks are essential to overcome institutional bottlenecks.
3. **Promote Community-Based Adaptation:** Adaptation measures should be localized and participatory, ensuring the active involvement of communities, women, and vulnerable groups in project design and implementation.

4. **Incentivize Renewable Energy Investment:** Nigeria should adopt incentive-based models such as feed-in tariffs, tax credits, and renewable energy auctions (as applied in South Africa) to attract private-sector participation.
5. **Increase Public Awareness and Capacity Building:** Awareness campaigns, technical training, and knowledge-sharing platforms should be established to enhance understanding and support for clean energy adoption at both urban and rural levels.
6. **Integrate Mitigation and Adaptation:** Policies should avoid treating mitigation and adaptation separately; instead, a synergistic approach that considers their interdependence in energy planning and climate resilience is needed.

In conclusion, while Nigeria has laid the groundwork for a climate-resilient energy transition, success will depend on bridging the gap between policy ambition and practical implementation through stronger governance, sustainable financing, and inclusive participation.

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