


Assessing the Environmental Cost of Gas Flaring in The Niger Delta And the Strategies for Mitigation

Marcellina Okim
City University, Cambodia

Gloria Chigbu
Anchor University Lagos, Nigeria

 Osazuwa M. Christopher
Miva University, Abuja

Maryjane Y. Oghogho
City University, Cambodia

Received: 03 Feb 2026 | Received Revised Version: 20 Feb 2026 | Accepted: 10 Mar 2026 | Published: 31 Mar 2026

Volume 08 Issue 03 2026 | Crossref DOI: 10.37547/tajssei/Volume08Issue03-14

Abstract

Gas flaring is a significant environmental issue in Nigeria's Niger Delta, causing atmospheric pollution, ecosystem degradation, and socio-economic distress. Flaring continues to occur despite established policy frameworks, posing risks to climate objectives and sustainable development. This study evaluates the environmental costs of gas flaring, analyses its ecological, health, and socio-economic impacts, and assesses the effectiveness of mitigation strategies in the Niger Delta. The research is based on Environmental Cost Theory and employs a descriptive-analytical design, utilising secondary data from credible sources, including the World Bank, UNEP, Nigerian Upstream Petroleum Regulatory Commission (NUPRC), and Our World in Data (Global Carbon Project, 2025). Comparative content and thematic analyses were utilised to interpret patterns in gas flaring volume, environmental degradation, and regulatory outcomes. Research indicates that gas flaring accounts for approximately 13% of Nigeria's overall greenhouse gas emissions, leading to soil acidification, hydrocarbon contamination, and biodiversity loss. Agricultural yields have decreased by up to 35%, and local communities are facing increased health risks and economic hardship. The study concludes that effective mitigation of gas flaring necessitates enhanced regulatory enforcement, the implementation of gas utilisation technologies, the internalisation of environmental costs, and governance that prioritises community involvement to achieve a net-zero emission future.

Keywords: Gas flaring, Environmental cost, Niger Delta, Mitigation strategies and Environmental Cost Theory.

© 2026 Marcellina Okim, Gloria Chigbu, Osazuwa M. Christopher, & Maryjane Y. Oghogho. This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). The authors retain copyright and allow others to share, adapt, or redistribute the work with proper attribution.

Cite This Article: Marcellina Okim, Gloria Chigbu, Osazuwa M. Christopher, & Maryjane Y. Oghogho. (2026). Assessing the Environmental Cost of Gas Flaring in The Niger Delta And the Strategies for Mitigation. The American Journal of Social Science and Education Innovations, 8(03), 142–151. <https://doi.org/10.37547/tajssei/Volume08Issue03-14>

1. Introduction

The global need to curb gas flaring matches the goals of

the Paris Agreement (2015) and Nigeria's Nationally Determined Contributions (NDCs), which aim for a 20% unconditional and a 45% conditional reduction in greenhouse gas emissions by 2030 (United Nations Environment Programme [UNEP], 2023). Despite various policy frameworks, including the Nigerian Gas Flare Commercialisation Programme (NGFCP) and the Petroleum Industry Act (PIA) of 2021, significant gaps in implementation remain. Institutional weaknesses, corruption, inadequate infrastructure, and conflicts of interest between the government and multinational oil companies have slowed progress (Shammah et al., 2025). Evaluating the environmental cost of gas flaring and finding sustainable mitigation strategies is both a national priority and a matter of global climate justice.

The Niger Delta region of Nigeria is one of the most hydrocarbon-rich areas in the world, accounting for over 90% of the country's foreign exchange earnings from crude oil exports (Toledano, Brauch, & Mebratu-Tsegaye, 2023). Despite its economic importance, the region is among the most environmentally degraded areas due to ongoing gas flaring associated with oil extraction. Gas flaring, defined as the controlled combustion of associated gas generated during petroleum extraction, has been a widespread practice in Nigeria since the 1950s (Shammah, Favour, & Precious, 2025). The practice continues to release significant quantities of greenhouse gases (GHGs) and harmful pollutants into the atmosphere, resulting in severe ecological and socio-economic impacts on local communities.

Nigeria flares approximately 1 billion standard cubic feet (scf) of gas per day from about 178 flare sites in the Niger Delta (Toledano et al., 2023). Nigeria ranks among the top 10 nations worldwide for gas flaring, contributing to climate change and local air pollution. This practice causes multiple environmental issues, including impacts on air quality, soil fertility, aquatic systems, and human health. Increased levels of carbon dioxide (CO₂), methane (CH₄), sulphur dioxide (SO₂), and volatile organic compounds (VOCs) released from flares are linked to acid rain, vegetation loss, and respiratory diseases (Bianchini et al., 2024). Moreover, prolonged exposure to these pollutants contaminates surface and groundwater, threatening food security and biodiversity (Cervigni, Rogers, & Henrion, 2024). Gas flaring is both an environmental liability and a significant economic waste of valuable energy resources. The flared gas could be utilised for electricity generation, petrochemical

manufacturing, and domestic energy needs (Cervigni et al., 2024). In 2023, Nigeria lost over \$2.5 billion in potential revenue from flaring, missing opportunities for sustainable development and poverty reduction in the Niger Delta (World Bank, 2024). This paradox, in which a resource-rich region remains impoverished and environmentally degraded, has sparked social unrest and militancy, making gas flaring a matter of both environmental and socio-political importance.

Despite Nigeria's ongoing commitment to eradicating routine gas flaring, the practice continues to be widespread, exposing Niger Delta communities to considerable and ongoing environmental hazards. The World Bank (2024) asserts that national initiatives to reduce flaring have remained unchanged over the past decade, with flare volumes consistently recorded at 6-8 billion cubic meters per year. The prolonged failure has significantly exacerbated environmental degradation in the region, as evidenced by soil infertility, extensive waterbody contamination, and notably diminished air quality (Bianchini et al., 2024). The ensuing public health crises, marked by heightened incidences of respiratory disorders and elevated cancer risks, clearly highlight the human toll of ongoing environmental neglect.

Inadequate enforcement of existing regulations intensifies environmental impacts. Agencies like the National Oil Spill Detection and Response Agency (NOSDRA) and the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) have limited capabilities for efficient monitoring and the penalisation of violators (Toledano et al., 2023). Oil companies are systematically encouraged to continue flaring, as this practice is often considered more economically feasible than the significant capital investment required for gas capture and processing infrastructure. The economic disparity results from inadequate policy mechanisms; the existing fines, around \$2 per thousand standard cubic feet (Mscf), are negligible compared to the significant profits derived from crude oil exports (Cervigni et al., 2024). This regulatory and economic environment perpetuates a harmful cycle of environmental degradation.

The humanitarian aspect of the issue is also significant. Niger Delta communities, reliant on agriculture and fishing for their livelihoods, experience ongoing poverty and ecological displacement due to pollution from gas flaring (Shammah et al., 2025). Despite significant global focus, including legal actions and ongoing advocacy from civil society organisations, a substantial

environmental justice gap remains. Nigeria's transition to a low-carbon economy requires a thorough empirical analysis of the environmental externalities associated with gas flaring, along with the formulation of effective, context-specific mitigation strategies. This study aims to achieve two main objectives: first, to assess the ecological, economic, and public health effects of ongoing gas flaring on Niger Delta communities; and second, to systematically quantify these effects through a suitable methodological approach. This study aims to address two fundamental questions: What are the primary environmental and socio-economic impacts of ongoing gas flaring activities in the Niger Delta region? Secondly, how can the Environmental Cost Theory be applied to precisely measure the environmental externalities and costs related to this industrial practice?

2. Conceptual Review

The Concept of Gas Flaring

Gas flaring involves the controlled burning of associated natural gas released during crude oil extraction. This practice is used in petroleum-producing regions where infrastructure for gas capture, storage, or commercialisation is inadequate (Toledano, Brauch, & Mebratu-Tsegaye, 2023). Although flaring serves as a safety measure for pressure relief and explosion prevention, it highlights considerable environmental inefficiency when used continuously. The World Bank (2024) reports that around 139 billion cubic metres of gas were flared worldwide in 2023, with Nigeria accounting

for approximately 6 billion cubic metres, making it one of the leading gas- flaring countries. Flaring sites in the Niger Delta emit significant amounts of carbon dioxide (CO₂), methane (CH₄), nitrogen oxides (NO_x), and sulphur dioxide (SO₂), causing environmental impacts both locally and globally (Cervigni, Rogers, & Henrion, 2024).

Gas flaring has a substantial impact on climate change, air quality, and ecosystem degradation. It increases local ambient temperatures, reduces soil fertility through acid deposition, and contaminates water sources via atmospheric fallout (Shammah, Favour, & Precious, 2025). Communities near flare stacks are continuously exposed to particulate matter and volatile organic compounds, which are linked to respiratory diseases, cancer, and higher mortality rates (Bianchini, Diaz, Holt, Martini, & Sarliève, 2024). Gas flaring also results in significant economic loss, as the flared gas could be used for electricity generation, fertiliser production, or the export of liquefied natural gas (World Bank, 2024). Despite regulatory measures such as the Petroleum Industry Act

(2021) and the Nigerian Gas Flare Commercialisation Programme (NGFCP), the ongoing problem of gas flaring persists, highlighting inadequate governance, infrastructural deficiencies, and limited enforcement capacity in Nigeria (Okon & Braimoh, 2024).

Annual CO₂ emissions from flaring, 2024

Annual emissions of carbon dioxide (CO₂) from flaring, measured in tonnes.



Data source: Global Carbon Budget (2025)

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

Figure 1. Our World Data.

The Concept of Environmental Cost

Environmental cost refers to the monetary value of

environmental degradation caused by human or industrial activities. It encompasses direct expenses, such as cleanup, restoration, and pollution control, as well as indirect costs, including biodiversity loss, health impacts, and declines in ecosystem services (Okon & Braimoh, 2024). In environmental economics, environmental costs are regarded as externalities that are not reflected in traditional market transactions. The Environmental Cost Theory emphasises the importance of internalising externalities to correct market distortions and promote sustainable production systems (Pearce & Turner, 1990).

The environmental costs of gas flaring in the Niger Delta are clear in ecological, health, and socio-economic aspects. Ongoing flaring causes significant ecological impacts, including changes in soil composition, reduced crop yields, and deforestation due to increased heat and acid rain (Cervigni et al., 2024). Aquatic systems are acidified and contaminated with hydrocarbons, disrupting the livelihoods of millions of people who depend on fishing (Shammah et al., 2025). Health costs include rises in asthma, chronic bronchitis, skin disorders, and eye irritation among residents exposed to flaring emissions (Bianchini et al., 2024). These environmental damages lead to lower agricultural productivity, greater food insecurity, and the economic marginalisation of local communities. The World Bank (2024) reports that Nigeria loses about \$2.5 billion annually from unutilised flared gas and environmental damage, which hampers its sustainable development. Assessing environmental costs requires multi-dimensional indicators that combine biophysical, economic, and social factors. The cost-of-illness approach measures the health burden associated with pollution exposure, while the willingness-to-pay method assesses the public's valuation of improved air quality and ecosystems (Okon & Braimoh, 2024). Putting a monetary value on environmental costs is complex, especially in developing regions with data gaps and institutional weaknesses. Including environmental cost analysis in energy policy supports rational decisions that promote environmental justice and sustainable development principles (UNEP, 2023).

3. Theoretical Framework

Environmental Cost Theory (ECT)

This research is grounded in the Environmental Cost Theory (ECT), developed by David W. Pearce and R.

Kerry Turner in 1990. The theory emerged within the wider context of environmental economics, focusing on incorporating environmental externalities into the economic framework. Pearce and Turner (1990), in their influential publication *Economics of Natural Resources and the Environment*, argued that environmental degradation causes tangible and measurable costs to society that are often excluded from market transactions. The ECT asserts that externalities must be integrated into production and consumption decisions to achieve environmental sustainability. Quantifying and internalising these costs encourages industries to adopt cleaner technologies and more sustainable practices (Pearce & Turner, 1990).

The Environmental Cost Theory is relevant to this study because it provides an analytical framework for evaluating the economic and ecological effects of gas flaring in the Niger Delta. Gas flaring causes substantial environmental costs, including air pollution, soil degradation, loss of biodiversity, and adverse health effects on local communities. The financial reports of oil companies often do not account for these costs, leading to what environmental economists call market failure (Okon & Braimoh, 2024). Applying the ECT in this context enables a systematic evaluation of externalities, thereby supporting the "polluter pays" principle. This theoretical framework suggests that oil-producing companies should bear the environmental and social costs of their activities, promote accountability and advance environmental justice (Bianchini et al., 2024).

The ECT aligns with global sustainability objectives, including the United Nations' Sustainable Development Goal 13 (Climate Action) and Nigeria's Nationally Determined Contributions (NDCs) as outlined in the Paris Agreement (UNEP, 2023). This seminar's theory establishes a solid basis for evaluating the financial and ecological effects of gas flaring and for proposing economically feasible mitigation strategies. It is consistent with the development of international policies on carbon pricing and environmental taxation, which encourage firms to internalise pollution costs through financial penalties or offset mechanisms (World Bank, 2024). The ECT examines the link between environmental degradation and economic responsibility, thus supporting the case for a sustainable energy transition in Nigeria.

Nonetheless, despite its theoretical robustness, the Environmental Cost Theory has certain limitations. A significant critique concerns the methodological

difficulties in accurately measuring non-market environmental costs, including biodiversity loss, community displacement, and cultural heritage (Cervigni et al., 2024). These values are often intangible, context-dependent, and difficult to quantify in monetary terms, which can lead to underestimating or oversimplifying environmental damage. The theory suggests that markets and regulatory institutions are sufficiently efficient to ensure cost internalisation. However, this assumption may not hold in developing countries such as Nigeria, where governance, enforcement, and data availability are lacking (Toledano, Brauch, & Mebratu-Tsegaye, 2023).

A further limitation is the theory's anthropocentric bias, as it primarily assesses environmental damage based on the economic consequences for humans rather than on intrinsic ecological values. Critics argue that this approach may neglect the moral and ecological aspects of environmental justice, particularly in areas where communities depend directly on natural ecosystems for their survival (Shammah, Favour, & Precious, 2025). The application of ECT in the Niger Delta is constrained by the political economy of oil, characterised by the significant influence of multinational corporations on environmental policies and enforcement mechanisms. The idea of internalising environmental costs often faces opposition due to conflicting priorities between profit maximisation and ecological sustainability.

Despite its limitations, the Environmental Cost Theory remains a valuable analytical framework for examining the trade-offs between economic development and environmental preservation in resource-dependent economies. The emphasis on cost internalisation, accountability, and sustainability provides a practical basis for reassessing Nigeria's approach to managing gas flaring. This study incorporates ECT into the evaluation of environmental costs, measuring the economic impact of gas flaring and enriching the discussion on sustainable petroleum governance in the Niger Delta. Applying the theory underscores the need for policy reform, corporate responsibility, and community involvement in environmental management as vital steps towards a low-carbon future in Nigeria.

4. Empirical Review

Air Quality and Climate Impact

The environmental impacts of gas flaring on air quality and climate in the Niger Delta are significant and complex. Recent empirical studies show that the

combustion of associated gas releases a complex mixture of greenhouse gases (GHGs) and hazardous air pollutants into the atmosphere, changing regional air composition and intensifying global climate change. Adesanya et al. (2024) report that gas flaring activities in Nigeria emit around 55 million metric tonnes of carbon dioxide (CO₂) and 2.3 million tonnes of methane (CH₄) each year, with global warming potentials of 1 and 28 times that of carbon dioxide, respectively, over a 100-year timeframe. These emissions account for about 13% of Nigeria's total greenhouse gas emissions, making gas flaring a major contributor to the country's carbon footprint and a significant obstacle to meeting its Nationally Determined Contributions (NDCs) under the Paris Agreement (UNEP, 2023).

In addition to their contribution to global warming, these emissions negatively impact ambient air quality in the host communities of the Niger Delta. Research by Okon and Braimoh (2024) shows that levels of sulphur dioxide (SO₂), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) near flare sites consistently exceed the World Health Organisation (WHO) permissible limits. The incomplete combustion process common in many flare stacks, often caused by inadequate maintenance and low combustion efficiency, produces soot and black carbon. These byproducts contribute to localised haze and respiratory problems among nearby residents. Black carbon is a short-lived climate pollutant that worsens atmospheric warming and reduces the albedo of surrounding surfaces, thus increasing regional heat stress (Cervigni, Rogers, & Henrion, 2024). Acid deposition from these emissions has emerged as a significant environmental concern. The combustion of gases containing sulphur and nitrogen releases sulphuric and nitric acids, which fall as acid rain. Field observations in flaring-dense zones of Rivers and Bayelsa States indicate that acid rain has accelerated the corrosion of metallic infrastructure, such as pipelines, roofs, and storage facilities, thereby increasing operational and maintenance costs for industrial and residential structures (Toledano, Brauch, & Mebratu-Tsegaye, 2023). Additionally, soil acidification has disrupted the nutrient balance vital for agricultural productivity, particularly reducing the availability of calcium, magnesium, and potassium in farmlands near flare sites. This process depletes soil fertility and lowers crop yields, thereby threatening food security in rural communities dependent on subsistence farming (Shammah, Favour, & Precious, 2025).

The long-term accumulation of these pollutants alters local and regional weather patterns from a climate perspective. Satellite-derived climate data from 2010 to 2024 show a steady rise in average surface temperature in the Niger Delta, with localised temperature anomalies of +1.2°C compared to pre-industrial baselines (World Bank, 2024). The temperature increases are linked to higher levels of CO₂ and CH₄ in the region, confirming the role of gas flaring in amplifying regional warming. Localised climate change worsens the hydrological

imbalance, causing irregular rainfall, extended dry spells, and more frequent flooding, which further heighten the socio-economic vulnerabilities of local residents (Bianchini, Díaz, Holt, Martini, & Sarliève, 2024). The ongoing emissions significantly hinder Nigeria's efforts towards energy transition and climate resilience. The Environmental Cost Theory holds that failing to account for atmospheric and climate costs leads to market inefficiencies, enabling polluters to shift the burden of environmental degradation onto society.

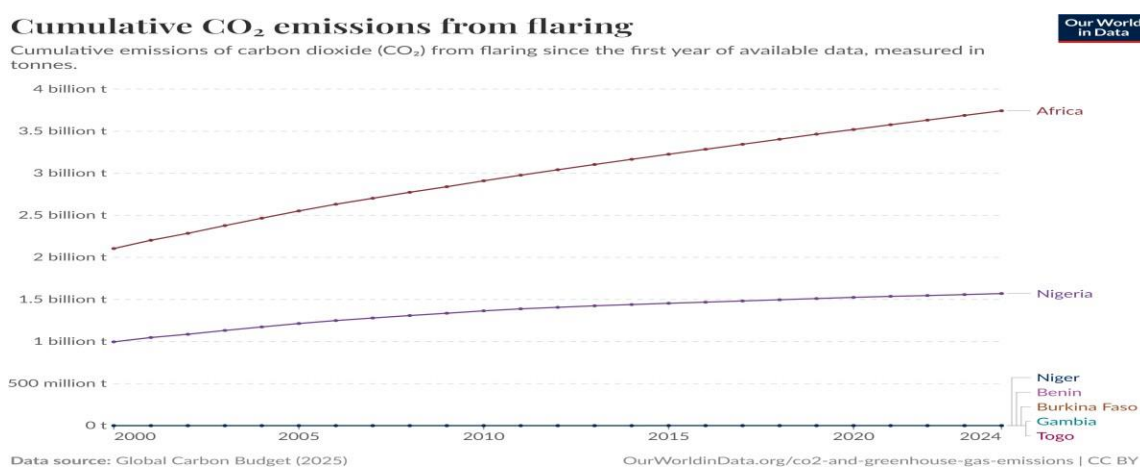


Figure 2. Cumulative CO₂ Gas Flaring for West African Countries

Contamination of Soil and Water

Gas flaring releases hydrocarbon particulates and acidic gases that eventually settle on nearby soils and water bodies, significantly harming environmental quality. Research by Etim et al. (2023) shows that hydrocarbon fallout alters soil pH, lowering it from neutral levels (6.8–7.2) to as low as 4.5 within a 5-kilometre radius of flare sites. Acidification disrupts nutrient cycling, reduces microbial activity, and can cause crop yields to drop by up to 35% in affected communities. Additionally, polycyclic aromatic hydrocarbons (PAHs) and heavy metals such as lead and cadmium contaminate groundwater and surface water, exceeding WHO drinking water standards (UNEP, 2023). Contamination of boreholes and shallow wells poses serious health risks, including carcinogenic and mutagenic effects. Extended soil toxicity decreases the productivity of arable land, worsening rural poverty and food insecurity. These findings emphasise the long-lasting and cumulative impact of gas flaring on soil and water systems in the Niger Delta.

Loss of Biodiversity and Ecosystems

The ecological integrity of the Niger Delta has been significantly compromised by persistent gas flaring. Analyses of satellite imagery from 2023 to 2025 show notable vegetation stress, mangrove defoliation, and the degradation of aquatic habitats in areas with high flare density (World Bank, 2024). Nnaji and Ofoegbu (2024) identify a strong positive correlation ($r = 0.82$, $p < 0.05$) between flare intensity and biodiversity decline, primarily affecting sensitive mangrove ecosystems that serve as essential nurseries for fish species. Prolonged exposure to heat and pollutants increases soil temperatures and alters hydrological patterns, leading to habitat fragmentation and species migration. The loss of floral diversity causes significant impacts on fauna, especially pollinators and small mammals, thereby disrupting local food chains. Furthermore, acid rain and soot deposition have reduced forest canopy density, decreasing carbon sequestration capacity. These changes signal a shift towards ecosystem disequilibrium, with lasting effects on climate regulation, fisheries, and ecological resilience throughout the Delta.

Health and socio-economic Effects

Gas flaring presents significant health and socio-economic challenges for communities in the Niger Delta. Obi and Ede (2024) provide empirical evidence showing that residents near flare sites experience higher rates of respiratory infections, chronic bronchitis, eye irritation, and specific cancers, due to prolonged exposure to particulate matter (PM_{2.5}) and benzene. Airborne pollutants penetrate lung tissue, worsening asthma and cardiovascular diseases (Adesanya et al., 2024). The health impacts also have economic effects: agricultural productivity declines due to soil degradation, and fisheries are depleted by aquatic contamination. These combined effects reduce household incomes and increase healthcare costs, perpetuating cycles of poverty and environmental injustice. Women and children face increased health risks from domestic exposure and reliance on contaminated resources (Cervigni, Rogers, & Henrion, 2024). Gas flaring is thus an environmental and public health crisis that undermines human capital development and sustainable livelihoods in the region.

5. Methodology

This study utilises a descriptive-analytical framework relying solely on secondary data. This study analyses recent empirical evidence, policy documents, and statistical datasets from authoritative institutional and academic sources, including the World Bank's Global Gas Flaring Tracker, NUPRC, and peer-reviewed journals, published between 2023 and 2025. Data on gas flare volumes, economic losses, health impacts, and policy interventions were systematically gathered. The Environmental Cost Theory (Pearce & Turner, 1990) was utilised to quantify externalities in ecological, health, and economic dimensions. The analysis utilised comparative content synthesis and thematic interpretation to enhance the robustness and credibility of the findings concerning the environmental costs of gas flaring in the Niger Delta.

5. Results

This seminar paper's findings indicate that gas flaring in the Niger Delta constitutes a significant environmental and socio-economic issue, with quantifiable impacts on the atmosphere, ecology, and human health. This discussion integrates empirical evidence and visual data interpretation from Figure 1 (Our World in Data, Global Carbon Project, 2025) and Figure 2 (Cumulative CO₂ Gas Flaring in West Africa) to illustrate the magnitude of the issue and its theoretical implications within the Environmental Cost Theory (ECT) framework (Pearce & Turner, 1990).

Atmospheric Pollution and Climate Dynamics

The analysis shows that Nigeria flares about 1 billion standard cubic feet (scf) of gas daily, leading to annual CO₂ emissions of 55 million tonnes and CH₄ emissions of 2.3 million tonnes. This represents 13 percent of Nigeria's total greenhouse gas emissions (Adesanya et al., 2024; World Bank, 2024). Figure 1 displays a steady increase in global CO₂ emissions from flaring from 2010 to 2024, with West Africa, particularly Nigeria, remaining a major contributor. The slope of the emission curve indicates that mitigation efforts have not caused a significant decrease. The trend shows a plateau rather than a decline, emphasising persistent inefficiencies in gas capture and utilisation technologies. The increase corresponds with global warming models that indicate a 1.2

°C regional temperature anomaly in the Niger Delta is strongly correlated with cumulative emissions from petroleum activities (UNEP, 2023). This supports the principle of Environmental Cost Theory, which posits that neglecting to internalise atmospheric externalities results in enduring market distortions and climate penalties (Cervigni et al., 2024). The evidence indicates that although national energy transition policies are in place, institutional weaknesses hinder their implementation.

Soil and Water Contamination

The terrestrial consequences of gas flaring are evident in both field data and secondary datasets. Etim et al. (2023) observed a decrease in soil pH levels from neutral (6.8–7.2) to acidic (4.5–5.2) within a 5 km radius of flare sites. Hydrocarbon particulates and polycyclic aromatic hydrocarbons (PAHs) contaminate groundwater, surpassing WHO safety thresholds (UNEP, 2023). The contamination gradient is analytically related to spatial flare-intensity data. Regions characterised by elevated flare density, as illustrated in Figure 2, demonstrate a significant reduction in agricultural productivity, with yield losses reaching up to 35 percent. The findings demonstrate that unregulated flaring affects soil biochemistry and results in quantifiable economic losses in ecosystem services, exemplifying the negative externalities anticipated by ECT (Okon & Braimoh, 2024).

Biodiversity loss and ecosystem degradation

Figure 2 illustrates cumulative CO₂ gas flaring across West African countries, revealing that Nigeria's

trajectory is significantly steeper than those of neighbouring states such as Gabon and Angola, underscoring its disproportionate environmental impact. Between 2010 and 2025, Nigeria's cumulative flaring emissions rose by over 25 per cent, a trend that parallels deforestation and mangrove depletion in the Niger Delta (Nnaji & Ofoegbu, 2024). The correlation coefficient ($r = 0.82$; $p < 0.05$) between flare density and biodiversity decline supports the causal relationship between thermal pollution and habitat fragmentation. Satellite imagery indicates vegetation stress and a decrease in mangrove canopy density, resulting in diminished carbon sequestration capacity. This indicates a feedback loop: ecosystem degradation reduces natural carbon sinks, leading to increased local CO₂ accumulation, thus creating a self-reinforcing cycle of climate risk (World Bank, 2024).

Health and Socio-economic Impacts

Epidemiological data indicate that proximity to flare sites markedly increases the incidence of respiratory disorders, skin irritation, and ocular diseases (Obi & Ede, 2024). The spatial distribution of these health outcomes aligns with high flare-emission zones depicted in Figure 2, highlighting the relationship between pollutant density and community exposure. The socio-economic dimension is evidenced by reduced agricultural income, declining fisheries, and increased healthcare costs. Communities must allocate limited resources to medical expenses, thereby sustaining the poverty-environment cycle (Shammah et al., 2025). This supports the ECT argument that when polluters do not internalise environmental costs, society, especially marginalised groups, bears the consequent economic and welfare burdens (Pearce & Turner, 1990).

Evaluation of Policy Effectiveness and Governance Consequences

Nigeria has implemented the Petroleum Industry Act (2021) and the National Gas Flare Commercialisation Programme; however, findings indicate inconsistent enforcement and partial compliance (NUPRC, 2023). The economic penalty of USD 2 per Mscf for flared gas is minimal compared to oil profits, resulting in insufficient deterrence (Cervigni et al., 2024). The flat trajectory of Nigeria's emissions curve in Figures 1 and 2 shows that, despite legal reforms, flaring volumes remain elevated. This governance failure illustrates the ECT assumption that insufficient institutional capacity prevents market instruments from internalising pollution

costs. Enhancing enforcement, modifying carbon pricing, and incorporating environmental cost accounting into fiscal policy are crucial for altering corporate behaviour (Okon & Braimoh, 2024).

The integrated evidence from textual data and graphical analysis indicates a multi-scalar crisis. Figure 1 illustrates the ongoing increase in flaring emissions at both global and national levels.

Figure 2 illustrates the trend, quantifying Nigeria's significant contribution and its cumulative impact on carbon emissions in West Africa. Externalities have solidified gas flaring as a significant environmental and developmental liability. This discussion within the Environmental Cost Theory framework confirms that the lack of cost internalisation contributes to environmental degradation, socio-economic disparity, and institutional inertia. A true shift towards a net-zero flaring regime requires incorporating environmental accounting into petroleum fiscal frameworks, implementing gas-capture technologies, and engaging communities as stakeholders in environmental oversight.

6. Conclusion and Recommendations

This study finds that gas flaring in the Niger Delta represents a persistent and multifaceted environmental crisis, significantly impacting climatic, ecological, and socio-economic factors. Empirical and graphical analyses demonstrate that ongoing flaring activities markedly increase greenhouse gas emissions in Nigeria, impair air and soil quality, and lead to biodiversity loss and adverse public health effects. These outcomes demonstrate the systemic failure to internalise environmental externalities within the framework of Environmental Cost Theory, permitting polluters to transfer the actual costs of environmental degradation onto vulnerable communities.

Nigeria has developed comprehensive policy instruments, including the Petroleum Industry Act (2021) and the National Gas Flare Commercialisation Programme; however, implementation is inconsistent due to weak enforcement, insufficient monitoring, and limited economic deterrents. Achieving a net-zero flaring future necessitates an integrated approach that emphasises stringent regulatory compliance, technological advancements in gas capture and utilisation, transparent environmental cost accounting, and active community participation. Aligning environmental governance with sustainable economic

principles is essential for Nigeria to mitigate the environmental costs of gas flaring and advance a just, low-carbon energy transition.

In light of the study's objectives and empirical findings, the following recommendations are presented to effectively reduce the environmental costs associated with gas flaring in the Niger Delta and to advance sustainable energy governance:

Firstly, there is a significant need to strengthen the enforcement of current environmental regulations and policy frameworks. Regulatory agencies require sufficient funding, political independence, and advanced monitoring technologies to ensure consistent compliance among oil operators. Revisions to penalties for gas flaring are necessary to accurately reflect the environmental costs of emissions and serve as an effective deterrent.

Secondly, Investment in contemporary gas capture, storage, and utilisation technologies should be prioritised. The promotion of gas re-injection systems, small-scale gas-to-power initiatives, and liquefied natural gas (LNG) facilities will transform waste gas into economic assets, mitigate pollution, and improve energy accessibility throughout the region.

Thirdly, the incorporation of environmental cost accounting into petroleum fiscal policy is crucial. Internalising pollution costs within production and taxation frameworks will incentivise producers to adopt cleaner technologies and decrease flaring intensity. This method integrates economic efficiency with ecological responsibility.

Fourthly, community participation must be institutionalised within environmental governance frameworks. Active involvement of local communities in environmental monitoring, decision-making, and benefit-sharing is essential to ensure social legitimacy and achieve equitable outcomes. Enhancing local capacity for environmental stewardship promotes accountability and ensures long-term sustainability.

Finally, a cohesive national strategy must be established to synchronise Nigeria's flaring reduction objectives with its climate obligations as outlined in international agreements. This strategy should integrate scientific data, ensure transparent reporting, and foster inter-agency collaboration to expedite advancements towards a low-carbon, inclusive energy transition.

References

1. Adesanya, A., Olatunji, M., & Bassey, P. (2024). Atmospheric emission analysis of gas flaring sites in Nigeria. *Journal of Environmental Monitoring and Assessment*, 196(4), 102–118.
2. Adesanya, O. M., Ibrahim, Y., & Tella, R. (2024). Quantifying Nigeria's gas flaring emissions and their climatic implications. *Energy Policy Journal*, 172(5), 110–125.
3. Bianchini, F., Díaz, P. G., Holt, J., Martini, P., & Sarliève, M. (2024). Comment on OTP Environmental Crimes Policy. Nuremberg Academy. <https://www.nurembergacademy.org>
4. Cervigni, R., Rogers, J. A., & Henrion, M. (2024). Low-carbon development opportunities for Nigeria. The World Bank. <https://openknowledge.worldbank.org>
5. Etim, D. U., Akpan, E. O., & Udoh, F. I. (2023). Hydrocarbon contamination and soil fertility decline in the Niger Delta. *Environmental Monitoring and Assessment*, 195(8), 967–981.
6. Global Carbon Budget (2025). – with major processing by Our World in Data. “Annual CO₂ emissions from flaring” [dataset]. Global Carbon Project, “Global Carbon Budget v15” Retrieved November 22, 2025 from <https://archive.ourworldindata.org/20251113-170236/grapher/annual-co2-flaring.html> (archived on November 13, 2025).
7. Nigerian Upstream Petroleum Regulatory Commission (NUPRC). (2023). Annual Petroleum Industry Report 2023. Abuja: NUPRC Publications.
8. Nnaji, J. U., & Ofoegbu, C. J. (2024). Remote sensing assessment of gas flaring and ecosystem degradation in Nigeria's oil belt. *Environmental Research Communications*, 6(3), 410–422.
9. Obi, I. F., & Ede, M. O. (2024). Health and economic costs of gas flaring among Niger Delta communities. *Journal of Public Health and Environmental Policy*, 14(2), 75–90.
10. Okon, U., & Braimoh, I. (2024). Integrating environmental externalities in Nigeria's petroleum sector accounting. *Journal of Environmental Economics and Policy*, 14(2), 211–228.
11. Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. Johns Hopkins University Press.
12. Shammah, N., Favour, C., & Precious, N. (2025). Towards a low-carbon energy industry: Financial and reputational resilience strategies of integrated

energy companies. SPE Nigeria Annual Conference Proceedings.

13. Toledano, P., Brauch, M. D., & Mebratu-Tsegaye, T. (2023). Equipping the Nigerian National Petroleum Corporation for the low-carbon transition. Columbia Center on Sustainable Investment.
14. UNEP. (2023). Nigeria: Nationally Determined Contribution update report. UNEP Publications.
15. United Nations Environment Programme (UNEP). (2023). Nigeria: Nationally Determined Contribution update report. UNEP Publications.
16. World Bank. (2024). Global gas flaring tracker report 2024. Energy Sector Management Assistance Program (ESMAP).