

Enhancing Methane Emissions Management in Nigeria's Oil and Gas Sectors: A Comprehensive Policy and Strategic Framework

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Abstract

This report examines the institutional framework for methane emissions reduction in Nigeria, with a particular focus on the Niger Delta region. Methane emissions in this area primarily stem from oil and gas extraction activities, including gas flaring and fugitive emissions. As one of the world's largest methane emitters, Nigeria owes much of its output to the Niger Delta's extensive oil extraction infrastructure. However, inconsistencies between local assessments and satellite data expose significant gaps in methane emission reporting, hindering accurate quantification and the implementation of effective mitigation strategies. Methane emissions in the Niger Delta have severe environmental and public health consequences, degrading air quality and exacerbating climate change. Despite the urgency, limited monitoring and reporting mechanisms constrain efforts to assess and address emissions comprehensively. Studies suggest that capturing flared gas could not only mitigate environmental harm but also provide economic and public health benefits. Nigeria has initiated steps to curb methane emissions, such as the 2018 Short-Lived Climate Pollutants Action Plan, which aims to end routine gas flaring by 2030. However, progress has been slow due to infrastructure deficiencies and enforcement challenges, underscoring the need for a stronger institutional framework. Addressing these barriers requires a coordinated effort among stakeholders, including government bodies, funding organizations, research institutions, and local communities. This report outlines actionable strategies for

reducing methane emissions, emphasizing the importance of stringent regulations, advanced monitoring systems, and incentives for cleaner technologies. It also proposes national and global policy recommendations that define clear objectives and foster collaboration among stakeholders. By prioritizing transparency, education, and community involvement, Nigeria can establish a cohesive framework to tackle methane emissions effectively, promoting environmental sustainability and driving economic growth.

Keywords

Methane Emissions, Oil and Gas Extraction, Gas Flaring, Fugitive Emissions, Policy Framework, Environmental Sustainability, Climate Change, Stakeholder Engagement, Monitoring Strategies, Niger Delta

1. Background

Methane is a potent greenhouse gas, contributing significantly to global warming, with a warming potential over 80 times that of carbon dioxide in its first 20 years of release [1]. Despite its short atmospheric lifespan, methane accounts for nearly half a degree Celsius of modern global temperature rise. Nigeria, one of Africa's largest oil producers [2]-[18], is particularly vulnerable due to emissions from energy production [19] [20], agriculture [21]-[32], and waste management [33]-[37]. While global efforts have focused on carbon dioxide, methane has been relatively overlooked [38]-[41]. In Nigeria, key methane sources include gas flaring [42], livestock farming, and landfill waste [43]. Recognizing this, the Nigeria Methane Emissions Reduction Pilot Programme (NiMERP), launched in collaboration with the United Nations Environment Programme, aims to provide accurate emissions data and inform mitigation strategies (Table 1) [44]. NiMERP employs both bottom-up and top-down data collection techniques, integrating satellite monitoring, on-ground measurements, and advanced modeling technologies [45]. The program highlights the potential for significant emission reductions in Nigeria's major methane-producing sectors [19]-[37]. Gas flaring in oil production remains a critical issue, with flared gas representing a substantial economic loss [43]. Agricultural emissions from livestock farming and methane release from landfills further contribute to the challenge [46]. While NiMERP's findings offer crucial insights, questions remain about the financial feasibility of mitigation technologies and their varying effectiveness across regions. Additionally, the socio-economic impact of methane reduction on urban versus rural communities requires further exploration. Addressing these concerns necessitates precise and comprehensive data collection to inform targeted policies [46]. The impact of methane emissions in Nigeria varies across communities. In the Niger Delta, where oil production is concentrated, methane pollution has severe environmental and economic consequences [43]. Meanwhile, methane from livestock farming and waste mismanagement in urban centers exacerbates national greenhouse gas invento-

ries. NiMERP aims to provide baseline data, identify high-impact sectors, and guide policies aligned with Nigeria's commitment to reducing methane emissions by 30% by 2030 [46]. However, significant knowledge gaps persist, requiring continued collaboration among government agencies, private stakeholders, and international organizations. A well-informed methane reduction strategy will not only support Nigeria's climate commitments but also contribute to the global understanding of methane mitigation in developing economies.

Table 1. Methane reduction strategies by sector in Nigeria.

| Sector | Methane Reduction Strategy | Key Technologies/Interventions |
|-------------|---|---|
| Energy | Improved flaring practices, leak detection | Advanced monitoring (infrared, UAVs), methane capture |
| Agriculture | Enteric fermentation control, manure management | Feed additives, anaerobic digesters for manure |
| Waste | Improved waste management and methane capture | Landfill gas recovery, wastewater methane control |

Adapted from NiMERP [47].

Table 1 outlines the methane reduction strategies specific to each sector, focusing on technological and policy interventions.

2. Current Methane Landscape in the Niger Delta, Nigeria, and Africa at Large

Methane emissions in Nigeria are predominantly driven by the oil and gas sector, which accounts for approximately 60% of the country's total methane output. Key contributors include gas flaring, venting, and leaks from aging infrastructure [44] [48]-[51]. Despite initiatives like the Nigerian Gas Flare Commercialisation Programme, gas flaring remains widespread, with Nigeria ranking among the top gas-flaring nations globally. The International Energy Agency (IEA) estimates that offshore oil production contributes 48% of Nigeria's methane emissions, followed by onshore oil operations at 30%, onshore gas at 10%, and gas and LNG facilities at 6%. Efforts to mitigate these emissions include the Nigerian Upstream Petroleum Regulatory Commission's (NUPRC) guidelines mandating operators to develop greenhouse gas management plans and conduct regular Leak Detection and Repair (LDAR) inspections [44] [48]-[51]. Agriculture is another significant source, contributing 49% of Nigeria's methane emissions. Livestock farming, particularly cattle, is the primary contributor due to enteric fermentation and manure management. Rice cultivation adds approximately 7% of agricultural methane emissions, mainly from anaerobic conditions in flooded paddies. These emissions are challenging to control, especially in rural areas with limited access to methane-reducing technologies. The waste sector accounts for 21% of methane emissions, with urban centers like Lagos and Port Harcourt being hotspots due to poorly managed landfills. Lagos State, for instance, generates about 13,000 tonnes of

waste daily, with a significant portion emitting methane. The state government aims to reduce methane emissions by 20% by 2030 and 45% by 2035 through improved waste management strategies [48]-[51]. Comparatively, Nigeria's methane emissions profile aligns closely with Angola, where oil production and inadequate enforcement of flaring regulations are prevalent. Angola's Zero Flaring Initiative, launched in 2022, achieved a 20% reduction in flaring over three years by implementing satellite-linked fines and gas capture incentives. In contrast, Egypt faces higher agricultural methane emissions due to its irrigation-intensive rice production. Egypt has mandated LDAR protocols and secured World Bank-funded infrastructure upgrades, resulting in a 35% reduction in methane leaks since 2021. Nigeria could benefit from adopting Angola's penalty-reward model and Egypt's financing strategies to enhance its methane reduction efforts. Without effective mitigation measures, methane emissions in Nigeria are projected to rise, driven by expanding oil production and agricultural activities. **Table 2-Table 5** and **Figure 1** below summarize methane emissions data across sectors in Nigeria, Angola and Egypt.

Table 2. Methane emissions by sector in Nigeria.

| Sector | Methane Contribution (%) | Methane Emissions (Gg) | Key Sources |
|-------------|--------------------------|------------------------|---|
| Oil & Gas | 60% | 4432.19 | Flaring, venting, leaks from infrastructure |
| Energy | 30% | 2245.41 | Gas production, flaring, transportation |
| Agriculture | 49% | 3578.80 | Livestock (enteric fermentation) (40%), rice cultivation (9%) |
| Waste | 21% | 1562.80 | Municipal solid waste, landfills |

Gigagrams (Gg), Adapted from FME [50].

Table 2 presents the methane emissions in Nigeria, broken down by sector. Agriculture is the largest contributor, followed by the energy sector, and finally the waste sector.

Table 3. Comparative analysis with Angola and Egypt.

| Country | Key Challenges | Strategies | Lessons for Nigeria |
|---------|-------------------------------------|---|---|
| Angola | High flaring (ranked 2nd in Africa) | Zero Flaring Initiative (2022): fines for non-compliance + gas capture incentives | Adopt Angola's penalty-reward model |
| Egypt | Aging infrastructure leaks | Mandated LDAR + World Bank-funded upgrades | Leverage international financing for infrastructure |
| Nigeria | Underreporting + weak enforcement | NiMERP (pilot monitoring) | Scale NiMERP with Angola/Egypt's regulatory rigor |

Angola reduced flaring by 20% in 3 years via satellite enforcement, while Nige-

ria's lack of similar accountability mechanisms hinders progress.

Table 4. Methane emissions by sector and sub-sector in Nigeria

| Sector | Sub-Sector | Methane Emissions (Gg) | Contribution (%) |
|-------------|-----------------------|------------------------|------------------|
| Energy | Gas Production | 1796.33 | 24 |
| Energy | Oil Production | 224.54 | 3 |
| Energy | Gas Flaring | 224.54 | 3 |
| Agriculture | Enteric Fermentation | 2863.04 | 40 |
| Agriculture | Manure Management | 71.58 | 1 |
| Agriculture | Rice Cultivation | 250.14 | 7 |
| Waste | Municipal Solid Waste | 171.91 | 11 |
| Waste | Wastewater | 156.28 | 10 |

Table 4 detailed breaks down of methane emissions into sub-sectors, highlighting the major contributors such as gas production and enteric fermentation in agriculture.

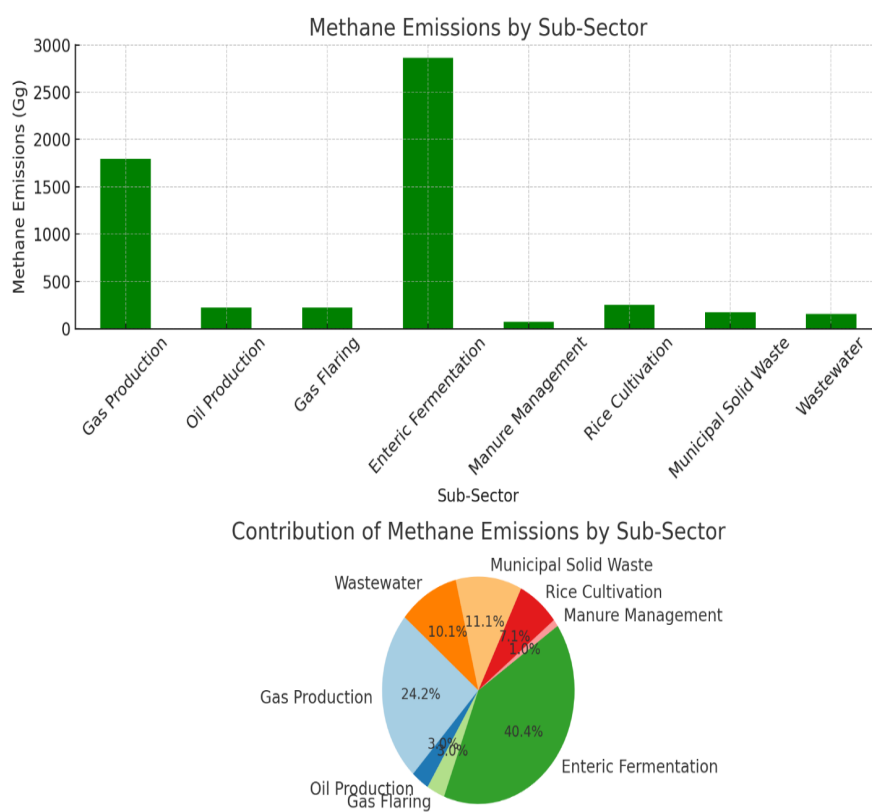


Figure 1. Bar chart (Top): methane emissions (Gg) by sub-sector; Pie chart (Bottom): the percentage contribution of each sub-sector to overall methane emissions. These visuals help highlight which sectors contribute the most to methane emissions.

Table 5. Regional distribution of methane emissions in Nigeria.

| Sector | Key Regions | Emissions Sources |
|-------------|------------------------------------|-------------------------------------|
| Energy | Niger Delta | Flaring, oil and gas infrastructure |
| Agriculture | Rural Northern and Middle Belt | Livestock farming, rice paddies |
| Waste | Urban areas (Lagos, Port Harcourt) | Landfills, wastewater treatment |

Adapted from NBS [49].

This data offers insight into where methane reduction efforts can have the most impact. In the Niger Delta, improving flaring practices and monitoring gas leaks can help lower emissions in the energy sector. For agriculture, particularly in northern rural areas, the introduction of methane-reducing technologies, such as feed additives for livestock and better manure management systems, could lower emissions from livestock. Finally, improving urban waste management systems in cities will be essential for reducing methane from landfills. By addressing these key sectors, Nigeria and Africa at large can make significant progress toward methane emission reductions. The work conducted under NiMERP, using both satellite data and on-the-ground measurements, provides a solid foundation for future actions. These efforts, if sustained and expanded, will be essential for helping Africa meet both national and global climate goals.

3. Current Data on Methane Emissions in the Niger Delta

Methane emissions in the Niger Delta are primarily linked to oil and gas extraction activities, notably gas flaring and fugitive emissions. Nigeria, as one of the largest methane emitters globally, has a significant portion of its emissions stemming from the Niger Delta due to its dense concentration of oil infrastructure. Despite its importance, methane emission data from the region remains inconsistent. While national reports and international assessments, such as those from the International Energy Agency (IEA), suggest significant emissions, discrepancies between local data and satellite observations indicate underreporting and notable data gaps [52]. The environmental consequences of methane emissions in the Niger Delta are significant [53]-[58]. Methane contributes to global warming and forms ground-level ozone, which can cause respiratory health issues and damage ecosystems [38] [39] [42] [60]-[66]. Despite the region's major role in methane emissions, monitoring efforts have been insufficient, limiting a full understanding of the extent of the emissions (Table 5). Studies suggest that methane capture from flaring could bring both economic gains and public health benefits to the region [52]. However, progress on Nigeria's methane reduction commitments, such as the 2018 Short-Lived Climate Pollutants (SLCP) Action Plan, has been slow due to infrastructure and enforcement challenges.

Table 5 reflects methane emissions across different regions in Nigeria, highlighting key sources in each region.

4. Primary Methane Emission Sources in the Niger Delta

The Niger Delta's methane emissions are primarily driven by a few key sources:

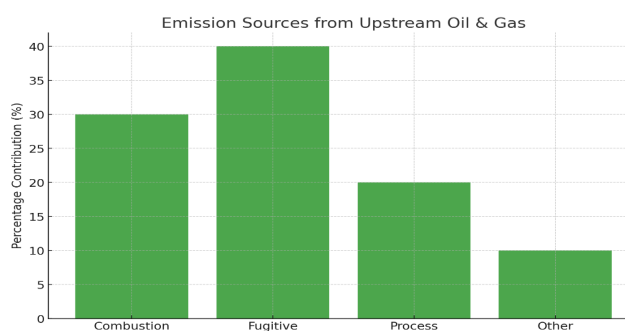
1) Gas flaring: This process of burning off natural gas during oil extraction is the largest source of methane in the region. Although gas flaring is intended to reduce methane, inefficient combustion allows substantial amounts to escape into the atmosphere [52].

2) Fugitive emissions: Methane leaks from oil pipelines, storage tanks, and other aging infrastructure due to poor maintenance. These leaks are often underreported because advanced monitoring technologies required for detection are not widely available in the Niger Delta [67].

3) Abandoned oil wells: Improperly sealed or maintained wells leak methane, a frequent issue in the Niger Delta's numerous inactive oil fields. This source of methane can continue unchecked for years if not addressed [68].

4) Incomplete combustion: During flaring, incomplete combustion of methane can occur, especially in older or poorly maintained equipment, leading to higher emissions [52].

These emission sources (**Figure 2**) result from operational inefficiencies, outdated technology, and a lack of regulatory oversight. Addressing these challenges will require stronger enforcement of environmental policies, investment in updated infrastructure, and the implementation of advanced monitoring systems.



Adapted from GMI [45].

Figure 2. Emission sources from Upstream Oil & Gas—a bar chart illustrating the percentage contributions of various emission sources.

Figure 2 presents the contribution of different sources (e.g., combustion, fugitive emissions) to the total emissions from upstream oil and gas operations. By identifying major contributors, **Figure 2** facilitates targeted mitigation strategies. Understanding these sources is essential for prioritizing efforts in emissions reduction. This visualization provides clarity on operational inefficiencies and environmental risks. It supports the development of technology-specific abatement measures.

5. Methods for Long-Term Methane Monitoring and Data Gaps

Monitoring methane emissions in the Niger Delta requires a multi-faceted approach, especially given the geographical and political complexities of the region. There are a few methods available, each with its own advantages:

1) Satellite remote sensing provides extensive coverage and is invaluable for detecting methane emissions from gas flaring and industrial activities in hard-to-access regions like the Niger Delta. While tools such as ESA's Sentinel-5P and the Methane Alert and Response System (MARS) which identified 1200 global super-emitters in 2023 have improved hotspot detection, their effectiveness in Nigeria is hampered by persistent cloud cover and a lack of ground validation. To address these gaps, hybrid systems combining satellites with drones (as piloted in Algeria (**Figure 4**), reducing emissions by 15%) offer a cost-effective solution for the Niger Delta [68]. However, ground-based sensors, though accurate, remain underutilized due to high costs, covering < 10% of oil fields. Hence, Nigeria should scale NiMERP's drone deployments and integrate Angola's rigorous enforcement model to enhance monitoring precision and accountability [68].

2) Ground-based sensors provide accurate, real-time methane leak data at specific sites, but their widespread deployment in Nigeria remains limited due to high infrastructure costs. Pilot projects in Port Harcourt demonstrated strong performance (80% accuracy), yet coverage extends to less than 10% of oil fields, highlighting scalability challenges. Targeted use in high-risk zones paired with satellite or drone validation could optimize cost-effectiveness while improving data reliability [67].

3) Mobile monitoring (drones/UAVs) equipped with methane sensors enable targeted surveillance of pipelines, flare sites, and abandoned wells, offering flexible deployment across Nigeria's oil fields. While successful pilots in Algeria achieved 15% emission reductions (**Figure 4**), the technology currently provides only snapshot data rather than continuous monitoring. Thus, a hybrid satellite-drone system would combine the Niger Delta's unique geographical advantages with cost-effective, periodic validation of satellite data while maintaining operational flexibility [52].

4) Infrared cameras are highly effective for detecting methane leaks from equipment and pipelines, but their utility in the Niger Delta is constrained by high costs and reduced accuracy during frequent high-humidity conditions [68]. While technologies like infrared cameras, drones, and satellites have shown promise in NiMERP pilots such as drone surveys in Ebocha-Obrikom that revealed previously undetected leaks, and infrared scans along the Trans Niger Pipeline that identified high-risk flare sites, although, key challenges remain. These include the lack of real-time data transmission, maintenance difficulties, and insufficient infrastructure for sustained operation. A hybrid monitoring system combining satellite coverage (for breadth), periodic drone deployments (for targeted validation), and strategically placed infrared cameras (for

high-priority infrastructure) would maximize detection capabilities while accommodating regional constraints. This approach requires parallel investments in training personnel and stabilizing power/network infrastructure to ensure long-term viability [68] [70].

6. Improving Methane Data Collection for Global Models

Data from the Niger Delta has the potential to enhance global methane emission models, particularly for African oil-producing regions. Global methane models rely on a combination of reported data and satellite observations, but underreporting and gaps in local data have led to an incomplete understanding of emissions from this region [67]. Incorporating more comprehensive data from the Niger Delta would improve the accuracy of these models. By integrating data from satellite monitoring, ground sensors, and mobile technologies, global methane models could better estimate actual emissions from oil and gas activities in the Niger Delta. This would not only strengthen climate models but also guide the implementation of mitigation efforts where they are most needed [52]. Improving methane monitoring in the Niger Delta could also help Nigeria meet its international climate commitments, such as those outlined in the Global Methane Pledge. Incorporating input from local communities, who often have firsthand knowledge of smaller emission sources like abandoned oil wells, is essential for collecting more accurate data. Engaging with local stakeholders can lead to better data collection and more targeted methane reduction strategies [68]-[70].

7. Economic and Health Implications of Methane Reduction

7.1. Economic Benefits of Methane Reduction

Reducing methane emissions in Nigeria offers significant economic benefits, particularly in the energy sector. Methane, the primary component of natural gas, can be captured and monetized instead of being lost through leaks or flaring. This not only reduces waste but also increases efficiency in oil and gas operations. For instance, using methane capture technologies helps companies recover a valuable resource, improving their bottom line while contributing to Nigeria's energy security. In addition to enhancing energy efficiency, investing in methane reduction technologies can stimulate job creation and open new markets. The captured methane can be repurposed for various uses, such as producing biogas in the agricultural and waste sectors, contributing to Nigeria's renewable energy goals (Global Methane Initiative [45]). Moreover, methane reduction investments align with Nigeria's broader economic development objectives. By creating opportunities for innovation in areas such as methane capture, companies can access new technologies, increasing the sector's overall productivity. This not only bolsters Nigeria's economy but also positions the country to attract foreign investments in clean energy technologies. **Table 6** summarizes the potential economic gains from methane reduction in key sectors.

Table 6. Economic and environmental benefits of methane reduction by sector.

| Sector | Economic Benefits | Environmental Benefits | Primary Activities |
|------------------|--|--|--|
| Energy | Improved efficiency, reduced waste, reduced flaring losses | Reduced greenhouse gas emissions, improved air quality | Methane capture in oil and gas production |
| Agriculture | Renewable energy production, job creation, biogas production | Reduced methane emissions from livestock | Biogas from livestock waste, methane reduction in rice paddies |
| Waste Management | Energy generation from waste, cost savings | Reduced methane emissions from landfills | Methane capture from landfills |
| Energy | Improved efficiency, reduced waste, reduced flaring losses | Reduced greenhouse gas emissions, improved air quality | Methane capture in oil and gas production |

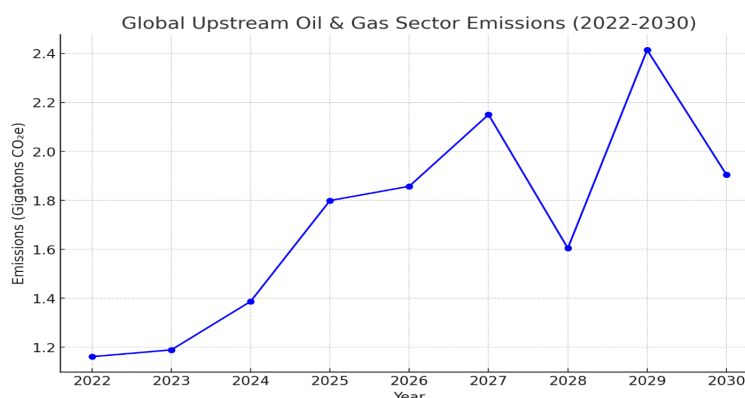
Adapted from GMI [45].

Table 6 details the benefits of methane reduction across various sectors, focusing on both economic gains and environmental improvements.

7.2. The Link Between Methane Reduction and Public Health

Reducing methane emissions significantly improves public health by enhancing air quality. Methane is a precursor to ground-level ozone, a pollutant linked to respiratory illnesses like asthma and increased cardiovascular disease risks. Urban areas such as Lagos and Port Harcourt, already facing high pollution levels, are especially vulnerable [6] [8] [33] [40] [60]-[63]. Mitigating methane emissions helps lower ozone formation, resulting in cleaner air and better health outcomes. Methane reduction in waste management also addresses public health risks. Landfills, a major methane source, emit odors and pathogens that contribute to disease spread. Improved landfill management and methane capture technologies not only reduce emissions but also create healthier environments, aligning public health and climate strategies [6] [8] [33] [40] [60]-[63]. The oil and gas sector is a critical target for methane reduction within broader decarbonization efforts. Methane from upstream operations accounts for 7% of global greenhouse gas emissions, with half resulting from leaks or flaring (**Figure 3**). Global initiatives such as the Global Methane Pledge and the Oil & Gas Decarbonization Charter aim to cut emissions significantly by 2030. If fully implemented, reductions of up to 600 million metric tons of CO₂ equivalent could be achieved [37]-[39] [71]. However, meeting these targets requires an estimated US\$200 billion investment in infrastructure to capture and repurpose methane. While costly, this strategy is economically viable due to its climate benefits and financial returns. Governments, corporations, and communities must collaborate to share costs and responsibilities [37]-[39] [63] [71]. Beyond air quality, methane emissions contribute to climate challenges such as extreme weather and reduced crop yields due to ozone exposure. Cutting methane emissions can help mitigate these risks and promote resilient communities. Integrating methane reduction into public health policies allows simultaneous progress on climate and health goals [6] [8] [33] [40] [60]-

[63]. With coordinated action, methane mitigation can enhance human health, food security, and environmental sustainability.



Adapted from GMI [45].

Figure 3. Global Upstream Oil & Gas Sector Emissions (2022-2030)—A line graph depicting the emissions trend over time.

This line graph highlights the trends in emissions from the upstream oil and gas sector between 2022 and 2030. It emphasizes the trajectory of emissions under current policies and practices, providing a baseline for assessing mitigation efforts. This data is critical for tracking progress against global emissions targets. The visualization supports stakeholders in identifying when interventions are most needed. It underpins policy-making for decarbonization strategies.

8. Collaborative Efforts and Funding Mechanisms

8.1. International Collaboration on Methane Reduction: Strategy, Partners, and Conditions

International collaboration remains a necessary pathway for Nigeria to accelerate methane mitigation. Global initiatives like the Global Methane Pledge (GMP), which aims to reduce methane emissions by 30% by 2030, give Nigeria access to technical guidance and a \$200 million funding pool through the United Nations Environment Programme [41] [45]. Nigeria's revised Nationally Determined Contribution (NDC) aligns with the GMP targets, but implementation gaps persist, particularly around monitoring, reporting, and enforcement. Conditional funding, similar to Egypt's World Bank-supported methane infrastructure upgrades, could incentivize measurable emissions reductions. Egypt received \$50 million in 2023 to support leak detection, monitoring, and facility upgrades, achieving a 35% reduction in methane leaks within two years [44] [45] [47] [48]. Nigeria could adopt similar strategies by tying funding access to verified emission reductions, leveraging existing tools like satellite-based Leak Detection and Repair (LDAR) protocols.

Collaboration with specific international bodies can strengthen Nigeria's technical, institutional, and financial capacity. The Global Methane Initiative (GMI) and Climate and Clean Air Coalition (CCAC) have both supported methane abatement

programs in developing countries. Nigeria can partner with GMI on project-level emission quantification and mitigation technologies, while CCAC can assist in developing methane policy guidelines and community training. The World Bank's Gas Flaring Reduction Partnership has already provided funding for similar programs in Africa, and Nigeria could benefit from applying for these grants. UNEP, through its International Methane Emissions Observatory, can support Nigeria in integrating satellite analytics into its national emissions inventory. However, these collaborations must be structured with clear, performance-based agreements, including defined deliverables, time-bound milestones, and third-party audits [41] [44] [45] [47] [48] [51]. To translate international cooperation into tangible results, Nigeria should prioritize capacity building and mutual accountability mechanisms. For example, partnering with the Niger-Delta Institute for Emerging and Re-Emerging Infectious Diseases (NDIERID) and the Centre for Niger Delta Studies and Sustainability (CNDSS) to train regulators and analysts on satellite data interpretation can build local expertise and reduce over-reliance on foreign consultants. Knowledge-sharing platforms, co-developed pilot projects, and national-to-subnational data integration can support a robust methane monitoring system. **Table 7** below outlines key international partners, their roles, and potential collaborative activities. Integrating these actions into Nigeria's methane reduction roadmap will help close the implementation gap while meeting global expectations.

Table 7. Key international partners and funding programs for methane reduction in Nigeria.

| Partner/Program | Focus/Role | Potential Impact for Nigeria |
|--|---|--|
| Global Methane Pledge (GMP) | 30% methane reduction by 2030; technical guidance; funding access | Access to \$200M funding; supports verified emission cuts (UNEP, 2022) |
| UNEP Methane Partnership | Technical support, emissions data validation, reporting frameworks | Enhances knowledge transfer and capacity building |
| World Bank Gas Flaring Initiative | Infrastructure upgrades for gas flaring reduction | \$50M example grant to Egypt; applicable for facility modernization in Nigeria |
| Climate and Clean Air Coalition (CCAC) | Policy drafting, sub-national engagement, community training | Strengthens NDC integration and stakeholder participation |
| Global Methane Initiative (GMI) | Technology support and emissions tracking in energy, agriculture, and waste | Facilitates deployment of methane capture and monitoring technologies |
| UNEP Int'l Methane Emissions Observatory | Satellite-based methane monitoring and emissions validation | Provides transparency and supports reporting to global platforms |

Adapted and modified from UNEP [41].

8.2. Policy Framework and Regulatory Challenges

Reducing methane emissions in Nigeria requires a clear and enforceable policy framework grounded in practical implementation. Although Nigeria is a signatory to global commitments like the Global Methane Pledge and has developed documents such as the Short-Lived Climate Pollutants Action Plan (2018), actual enforcement remains inconsistent. Regulatory gaps persist, especially in the oil and gas

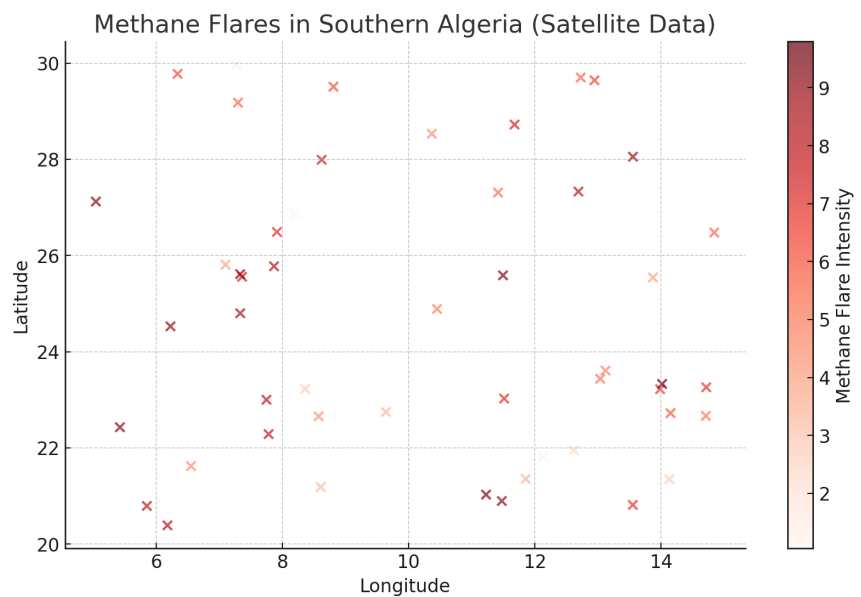
sector where methane leaks and flaring are not adequately tracked or penalized. Despite the existence of the Nigerian Gas Flaring (Prevention of Waste and Pollution) Regulations (2023), operators continue routine flaring without consequence in the Niger Delta, largely due to poor regulatory follow-up and limited data verification capacity [46] [50]. A major barrier is the weak institutional ability of regulatory bodies to monitor and enforce compliance. Agencies often lack technical expertise, real-time data systems, and legal autonomy to carry out inspections or impose sanctions effectively. This affects both national enforcement and sub-national oversight, especially in areas where local governments play a role in environmental governance. Moreover, methane data inconsistencies between company reports and satellite observations further limit transparency and hinder policy responsiveness. Strengthening governance will require targeted investment in staffing, analytical tools, and routine audit mechanisms, particularly in the oil-producing zones where methane intensity is highest. To address these challenges, Nigeria should introduce enforceable standards that mandate the installation of continuous methane monitoring systems at upstream oil facilities. These should be accompanied by a methane emissions trading framework to reward reductions and penalize excess emissions. A dedicated methane regulatory unit, possibly under the Nigerian Upstream Petroleum Regulatory Commission (NUPRC), could be tasked with independent verification, reporting, and enforcement. This unit would have the authority to issue fines, validate emissions data via satellite tools, and audit compliance across sectors. These steps will improve methane governance while also increasing Nigeria's credibility in meeting international climate obligations [38] [39] [46] [50].

9. Innovations and Awareness in Methane Management

9.1. Technological Innovations for Methane Monitoring and Reduction

Reducing methane emissions in Nigeria, where oil and gas (O&G), agriculture, and waste are key contributors, relies heavily on technological advancements. Remote sensing tools such as satellites and UAVs enable real-time monitoring, allowing precise detection of methane leaks in oil fields, which is essential for mitigation (**Figure 4**). Infrared cameras and leak detection systems at production sites further support early corrective actions. In agriculture and waste management, methane-reducing feed additives and biogas digesters for manure management show promise. Additionally, capturing methane from landfills not only cuts emissions but also provides an energy source. These innovations are crucial for transitioning to a low-emission economy [8] [33] [48] [59]. The O&G industry has the potential to reduce emissions significantly. Current technologies can abate up to 80% - 90% of methane emissions through energy efficiency improvements, flaring mitigation, and operational upgrades. Low-cost solutions, such as electrifying extraction equipment and capturing vented CO₂, require minimal effort. While some measures save costs, others, such as carbon capture and storage, demand greater investment. If widely implemented, these approaches could substantially

lower Nigeria's O&G methane emissions, a crucial step given its global greenhouse gas contribution [48] [50]-[62]. Despite available solutions, the gap between ambition and action remains. The United Nations Environment Programme's International Methane Emissions Observatory reports that, despite better detection methods like the Methane Alert and Response System (MARS), emissions continue to rise. Since its launch in 2023, MARS has identified over 1200 major emission events worldwide, highlighting the need for Nigeria to move from detection to action. While initiatives like the Global Methane Pledge target a 30% reduction by 2030, only one-third of signatory countries have outlined actionable plans [50]-[52]. Governments are introducing regulations to drive methane reductions. Nigeria is implementing a methane fee to encourage reductions in the O&G sector, while the European Union is considering a "methane border adjustment" mechanism using satellite data to assess the emissions footprint of imported fuel. These regulatory efforts reflect growing recognition of methane's role in global warming. However, experts such as Drew Shindell emphasize the need for greater awareness of emissions levels and cost-effective abatement strategies, pointing to the importance of education alongside technology deployment [42] [48] [50]-[52]. Methane concentrations in the atmosphere are now 2.5 times pre-industrial levels, contributing to 30% of global warming. As noted at COP29, the energy sector offers the most immediate and cost-effective reduction opportunities. Achieving methane reduction targets will require stronger collaboration among governments, industries, and international organizations. For Nigeria, this means leveraging technology, enforcing regulations, and integrating mitigation strategies across all sectors to achieve a sustainable, low-emission future [38] [39] [48] [50]-[52].



Adapted from GMI [45].

Figure 4. Methane Flares in Southern Algeria (Satellite Data)—a scatter plot mapping methane flares based on satellite data, with intensity shown as color gradients.

The scatter plot maps show methane flares in Southern Algeria, showcasing spatial distribution and intensity based on satellite data. This visualization is crucial for monitoring localized methane emissions and identifying flaring hotspots. It helps assess the environmental and health impacts of methane releases. By linking specific sites to emission intensity, this chart facilitates targeted interventions. It underscores the role of advanced satellite monitoring in environmental governance.

9.2. Potential Barriers to Implementation

Several barriers could hinder the successful implementation of methane reduction strategies in Nigeria. One major challenge is the lack of sufficient domestic investment in methane reduction technologies. While international organizations provide some funding, the availability of local financing remains limited, particularly for the agricultural and waste sectors. Additionally, there is a lack of awareness among stakeholders, including local governments and farmers, about the importance of methane reduction [69]. Capacity-building initiatives are necessary to train personnel in methane monitoring and management. Overcoming these challenges will require a coordinated effort to mobilize both domestic and international resources, increase public awareness, and improve training and technical support across sectors.

9.3. The Role of Public Awareness and Education

Public awareness and education are crucial for driving methane reduction efforts. Educating key stakeholders including farmers, industry leaders, and local governments about the benefits of methane reduction can accelerate the adoption of mitigation technologies. For example, training programs that focus on sustainable livestock farming or proper waste management practices can help reduce methane emissions from agriculture and waste [34]-[36] [70]. Public campaigns should also highlight the potential economic benefits, such as job creation and renewable energy production. By making the economic and environmental advantages clear, you can foster a culture of sustainability and promote greater participation in methane reduction activities.

9.4. Monitoring Progress and Measuring Success

Tracking progress in methane reduction is essential for keeping Nigeria on course with its goals. Developing a national methane emissions inventory, regularly updated with field data and satellite monitoring, will provide a clear picture of emission trends. Setting specific benchmarks, such as reducing emissions by 10% by 2025 and 30% by 2030, can help maintain focus and accountability [50]. Regular progress reports can provide transparency and enable adjustments to strategies as needed. Collaborating with international partners will help Nigeria adopt advanced monitoring technologies and make data-driven decisions to improve methane management.

10. Actionable Steps for Stakeholders in the Niger Delta and Nigeria

Stakeholders at all levels can take defined roles in reducing methane emissions across Nigeria, especially in high-emission zones like the Niger Delta. Funding agencies, both public and private should prioritize investments in methane capture and leak detection technologies that reduce losses from flaring and infrastructure leaks. These investments must support not only the purchase of equipment but also the development of monitoring systems, emissions data platforms, and capacity building among implementers. Research institutions, such as universities and technical centers, should lead cross-sector studies to identify emission hotspots, evaluate interventions, and disseminate results. By working with local governments, these institutions can inform evidence-based policymaking. Community-level engagement is equally important. Many low-visibility methane sources like abandoned oil wells or illegal refining sites are best identified by those living nearby. Local communities can take part in methane abatement by assisting with monitoring, maintaining biogas systems, and reporting leaks. For this to be effective, partnerships with NGOs [66], educational institutions, and health organizations are necessary to provide training on emissions identification, methane risk awareness, and use of basic detection tools. Programs such as school curricula integration, mobile education units, and farmer field schools should be used to introduce sustainable agricultural practices like improved manure management and low-emission livestock feeding strategies. Lastly, policy coherence depends on sustained collaboration between institutions and consistent data reporting. Advocacy groups and environmental justice movements have a role in pressuring both national and subnational governments to enforce methane regulations. Community-based reward schemes tied to verified emission reductions can create incentives for ongoing participation. Furthermore, local governments can incorporate methane reduction into broader development plans and zoning policies. Continuous evaluation and public reporting of what strategies are working and where gaps remain will support adaptive management and inclusive participation. A coordinated approach linking public institutions, the private sector, civil society, and local knowledge will provide the structure needed to reduce methane emissions efficiently while protecting public health and supporting livelihoods (see **Table 8** below).

Table 8. Stakeholder action plan for methane emission reductions in Nigeria.

| Stakeholder | Role in Methane Reduction | Actionable Steps |
|----------------|--|---|
| Government | Policy-making, enforcement | Develop and enforce methane capture regulations |
| Private Sector | Technology investment, methane capture | Invest in methane-reducing technologies |
| Communities | Local implementation, awareness | Engage in methane reduction education and practices |

Continued

| | | |
|--------------------|-------------------------------|--|
| International Orgs | Funding and technical support | Provide funding and expertise for methane reduction projects |
|--------------------|-------------------------------|--|

Adapted from UNEP [41].

Table 8 outlines the roles of different stakeholders in the methane reduction strategy, focusing on collaboration and implementation.

11. Components of Methane-Related Policies

Effective methane reduction in Nigeria requires an integrated policy structure that combines regulation, financial incentives, and reliable monitoring. Existing frameworks, such as the 2018 Short-Lived Climate Pollutants (SLCP) Action Plan, provide a strategic baseline but lack enforceability. Key areas like gas flaring, fugitive emissions, and leaks from abandoned wells need to be addressed through clear legal standards backed by penalties. Private-sector compliance can be improved by offering tax incentives or grants for installing methane capture technologies. These incentives must be tied to measurable outcomes to justify public investment. Additionally, methane policies should prioritize education and outreach, particularly in oil-producing regions (see **Table 9** below). Joint campaigns by government agencies and NGOs can increase understanding of methane's health and environmental risks, helping to foster cooperation from industry and communities alike. Current policy gaps in Nigeria limit methane control efforts. Weak enforcement of flaring bans remains a major issue. Despite official reports indicating progress, satellite observations show persistent flaring in areas like the Niger Delta suggesting non-compliance is widespread and largely unpunished [52]. Discrepancies between reported emissions data and satellite findings [67] point to a lack of verification and transparency. Compounding this issue is the absence of mandatory Leak Detection and Repair (LDAR) protocols across most of the upstream oil and gas industry. Without these, early-stage leak identification is missed, allowing methane to escape unnoticed. These failures highlight the need for new legislation that mandates independent verification, improves access to emissions data, and introduces enforcement mechanisms that are resistant to political interference. To improve the current framework, Nigeria should implement three priority reforms. First, enforcement needs to include strict penalties linked to the volume of methane leaked for example, fines of \$5 per metric ton and license suspensions for repeat violations. Second, all oil operators should be required to deploy real-time monitoring systems, including infrared cameras and satellite-linked sensors, modeled after Angola's Zero Flaring Initiative. This would allow continuous emissions tracking and independent verification. Third, Nigeria could adopt a methane tax that applies to vented gas, with revenues directed toward local mitigation efforts, such as installing small-scale biogas systems or rehabilitating flare sites. This approach aligns with international examples like Canada's federal carbon pricing policy, which uses pollution fees to fund climate adaptation

in affected communities. These measures would bring clarity, accountability, and participation into Nigeria's methane policy framework (**Table 9**).

Table 9. Policy components for methane emission reductions in Nigeria.

| Sector | Policy Component | Implementation Strategy |
|-------------|---|---|
| Energy | Enforce stricter flaring regulations, incentivize capture | Tax incentives for methane capture technologies |
| Agriculture | Promote methane-reducing agricultural practices | Subsidies for sustainable farming and manure management |
| Waste | Improve waste management policies | Incentivize methane capture in landfills and wastewater |

Adapted from FME [50].

Table 9 summarizes the necessary policy components for reducing methane emissions in Nigeria across different sectors.

12. Example of Policy Statements: National and Global

12.1. National and Global Policy Frameworks for Methane Emission Reduction

A coherent national policy statement on methane emission reduction in Nigeria is very crucial. For example, one such statement might read: "Nigeria is committed to reducing methane emissions from the oil and gas sector by 50% before 2030 through eliminating routine gas flaring, minimizing fugitive emissions, and improving enforcement mechanisms." The policy outlines clear objectives of integrating regulatory and technological solutions with public-private partnership approaches toward national goals. Additional efforts of community engagement and locally reinforcing capacities can further assure implementation [72]-[75]. On a global scale, the framework could declare: "Signatories to the Global Methane Pledge will strive for a collective 30% reduction in methane emissions by 2030 compared to 2020 levels. This will be pursued through the adoption of advanced technologies, financial support for developing nations, and a collaborative exchange of best practices." This statement reinforces global cooperation while acknowledging the diverse capacities of countries to meet shared targets. Most importantly, it underlines the equity issue in the global response toward methane emissions. Both statements have echoed the need for harmony in local and international efforts. National policies fitted into the local realities, when put in line with global frameworks, can easily enable countries like Nigeria to make significant contributions toward global climate action [38] [39]. This synergy is important in ensuring methane reduction targets are ambitious yet attainable.

12.2. The Global Methane Pledge: Overview and Challenges

The Global Methane Pledge was unveiled at COP26 in 2021 to meet the urgent need for methane emissions reduction. To this commitment, more than 150 coun-

tries representing 55% of global methane emissions have signed on to reduce by 30%, by 2030. Methane's relatively short atmospheric life—approximately 15 years—makes it a priority for short-term climate warming mitigation, with tremendous heat-trapping properties, 80 times greater compared to carbon dioxide over 20 years [38] [39]. The pledge emphasizes the need for action across energy, agriculture, and waste management. Yet big hurdles persist: major emitters China, India, and Russia haven't signed on, holding down the global reach of this undertaking. Besides, standard mechanisms for monitoring and verification have not been established under this initiative, making the question of accountability among signatories an issue. Poor countries still need financial and technical means for the implementation of viable methods of methane reduction. All these gaps require sizeable investment and a sound system for tracking progress. Despite these findings, the GMP has catalyzed global momentum on methane action. It has brought about innovation in methane abatement technologies and increased international cooperation on the issue. Overcoming these remaining hurdles will be paramount to turning this pledge into measurable climate outcomes by 2030 [38] [39].

12.3. From Pledges to Action: A Roadmap

Meeting these GMP targets requires the integration of methane reduction into the larger climate agenda. Countries can draw upon their Nationally Determined Contributions under the Paris Agreement for an action framework. For instance, NDCs identify 476 methane mitigation activities across energy, agriculture, and waste sectors. Examples include gas flaring and venting reduction in the oil and gas industry, enhancement in livestock management, and organic waste diversion from landfills. These measures collectively target 40% of global methane emissions. Central to this pathway is prioritizing high-impact measures. Research shows that 13 key interventions, such as upgrading oil and gas infrastructure and improving manure management, can achieve more than half of the required reductions [13]. High methane-emitting countries, including the United States, China, and Nigeria, need to lead the way in implementing these measures. International cooperation will also be critical in addressing transboundary emissions and sharing best practices. This roadmap will need to be underpinned by strong political will, financial support, and community engagement. National governments should ensure that methane reduction policies are supported by public awareness campaigns and capacity-building initiatives. In addition, international climate finance mobilization will be necessary to support low-income countries in achieving their methane reduction targets.

12.4. Nigeria's Role and Achievements

Nigeria has also come to the fore in efforts at methane reduction. Its revised NDC contains a conditional target of 61% reduction in methane emissions by 2031, while key initiatives are on the implementation of methane guidelines, the phasing out of gas flaring, and integration of methane abatement into the national climate

strategies. In fact, this perfectly fits into the country's big vision of net-zero emission by 2060. In collaboration with CCAC and other international agencies, Nigeria has made good strides in methane monitoring and policy development. For example, the introduction of the Guidelines for Methane Emission Estimation in Nigeria is a serious attempt at regulating emissions in the oil and gas sector of Nigeria. In addition, joining global initiatives such as GMP shows that it cares about international climate actions. Despite these successes, significant challenges remain for Nigeria. The constraints of finance, infrastructure, and technical capacity are the principal barriers to the effective realization of methane reduction strategies in Nigeria. To overcome these, Nigeria needs to seize every opportunity at international forums, such as COP29, to demand climate finance and technical support. Strengthening domestic policies and fostering partnerships with the private sector will also be crucial [67]-[70].

12.5. Global Momentum and Next Steps

The GMP has catalyzed monumental progress in methane mitigation commitment, with over 158 countries committed to the pledge as of 2024. These countries collectively make up over 50% of global anthropogenic methane emissions. Key players like the International Energy Agency and the World Bank have supported this process through funding and technical assistance. Meeting the GMP 30% reduction target would avoid an estimated 260,000 premature deaths, 25 million tonnes of crop losses, and US\$10 billion in heat-related productivity losses every year [67]-[70]. To maintain this momentum, countries need to engage with three areas of work that are critical. Full embedding of methane mitigation into enhanced NDCs and alignment with nationally defined climate strategies, development of enhanced methane monitoring and reporting systems to ensure a track record of progress is delivered transparently, and international finance should prioritize methane reduction in a manner commensurate with the needs of the most resource-constrained countries. By addressing these priorities, the global community could realize significant gains in a much-needed reduction in emissions of methane. Immediate and long-term benefits will unfold as coordinated efforts in countries and internationally unlock methane mitigation's contributions for the planet and people.

13. Community Roles and Mobilization Strategies

Specific Community Roles in Methane Monitoring and Mitigation

1. Leak Detection and Reporting

1) Citizen Science Programs: Offer a cost-effective, high-impact approach to methane monitoring in underserved or high-risk areas like the Niger Delta. By equipping local communities with customized mobile applications such as MethaneSpotter and AirVisual adapted for offline use and available in local languages like Ibibio, Epie, Ogbia, Nembe, Ijaw, and English residents can document and geotag flares, leaks, or damaged infrastructure in real time [76]. These apps should include automated alert systems that notify both regulators (e.g., NUPRC) and oil

companies, with verified reports triggering timely inspections. The 2023 Bayelsa State pilot, demonstrated the model's effectiveness, generating over 1200 validated reports in six months, improving leak detection by 40%, and saving an estimated \$2 million in mitigation costs. To ensure sustainability and data quality, a "Community Methane Champions" initiative can be launched, offering certified two-week training at technical colleges, complete with field kits (gas detectors, thermal cameras), monthly performance-based stipends, and feedback mechanisms that show users how their data informs policy. Additional support measures such as SMS-based systems for non-smartphone users and subsidized data plans through telecom partnerships will help scale the initiative while enhancing community engagement and environmental literacy [72].

2) Community Surveillance Networks: Present a decentralized, cost-effective strategy for monitoring aging oil and gas infrastructure, including pipelines, flow stations, and abandoned wells. By training local volunteers to conduct regular inspections supported by tools such as handheld sensors, QR-coded site tagging, and low-cost methane detectors communities can play a vital role in early leak detection and infrastructure integrity assessment. App-based photo uploads enhanced with AI-assisted image analysis can help identify corrosion or damage, while a tiered alert system with a 24/7 hotline and mandated 72-hour operator response time ensures rapid follow-up, especially near sensitive sites like schools and hospitals. In high-risk areas like Ebocha and Gbaran, this approach can also help deter sabotage and artisanal refining. To sustain engagement and accountability, volunteers should be rotated and incentivized through stipends, performance-based rewards (\$5 - \$20 per verified report), or inclusion in local development programs. Community-led monitoring efforts co-managed by local governments, NGOs, and traditional leaders can supplement regulatory enforcement [66], reduce third-party damage incidents by up to 60%, and extend infrastructure lifespan by up to a decade, as shown by successful models in Alberta, Canada.

2. Sustainable Energy Initiatives

1) Landfill Biogas Cooperatives: Involve training local groups to collect, store, and repurpose methane gas released from waste decomposition at municipal dumpsites. These cooperatives can produce clean energy sources such as biogas for cooking or electricity generation for off-grid communities [20] [77] [78]. In Lagos, the Olusosun landfill has been part of pilot schemes where methane was extracted and used to power small generators and community kitchens. These models could be adapted in the Niger Delta, particularly in Port Harcourt, Yenagoa, and Warri, where landfill methane emissions remain high but largely untapped. Training should focus on safe handling of gas, equipment maintenance, and business development to support cooperative sustainability. With proper technical support from universities and NGOs, members can install biodigesters and simple gas storage units. Profits can be reinvested into health services, education, or waste collection improvements. Public-private partnerships can help subsidize the initial infrastructure while cooperatives manage day-to-day operations.

Table 6 above outlines the economic benefits of such circular economy models, including job creation and energy access improvements.

2) Flare-to-Energy Projects: Focus on capturing methane from oil and gas flaring sites and converting it into useful products like compressed natural gas (CNG), which can then fuel local transport or power microgrids. These projects offer a revenue-generating alternative to routine gas flaring, which continues to emit large volumes of methane despite existing bans. In partnership with host communities, government agencies, and private investors, such initiatives can be used to establish community-run CNG bottling points, small-scale filling stations, or generator leasing businesses. For instance, captured flare gas in Ughelli or Bonny could be redirected to power irrigation pumps or fish drying operations. Community members should be involved in project governance and trained in business operations, safety compliance, and equipment maintenance. Flare gas mapping using satellite and drone data can identify feasible locations. Income from gas sales can be reinvested in local infrastructure, such as schools or boreholes. These projects would not only reduce emissions but also improve local energy access and economic resilience.

3. Education and Mobilization Strategies

1. Awareness Campaigns

1) Health and Safety Workshops: Build awareness of the public health risks associated with methane exposure, particularly in oil-producing areas of the Niger Delta. Collaborations with institutions like Niger Delta University, Federal University Otuoke, Niger-Delta Institute for Emerging and Re-Emerging Infectious Diseases (NDIERID), Centre for Niger-Delta Studies and Sustainability (CNDSS) and local teaching hospitals can provide scientific and medical expertise. These workshops should focus on educating residents about methane's role in forming ground-level ozone, a respiratory irritant linked to asthma, bronchitis, and cardiovascular stress. Practical modules can cover flare site safety, early signs of methane exposure, and emergency response protocols. Community health workers and environmental officers can be trained to facilitate sessions in local dialects. Printed materials and posters, distributed via health centers and religious institutions, can reinforce key messages. Data collected during the sessions such as self-reported symptoms can also support health surveillance and environmental monitoring programs. These workshops serve as a bridge between technical research and community action, equipping residents to recognize and report health and environmental hazards associated with methane.

2) School Programs: Integrating methane literacy into primary and secondary school STEM curricula is essential for building long-term capacity and fostering environmental accountability among young people. Environmental education clubs in schools can serve as platforms for teaching students about the sources, risks, and mitigation of methane emissions. Lessons can include practical demonstrations using biogas kits, mobile sensors, or visual aids such as drone footage of flare sites. Competitions, debates, and science fairs can encourage student-led ad-

vocacy projects. Curriculum content should be developed in collaboration with education ministries and local NGOs, aligned with Nigeria's national STEM framework. Schools in regions like Bayelsa, Rivers, and Delta States should be prioritized due to proximity to emission hotspots. Training for teachers can be conducted during holiday periods, supported by digital teaching resources in English and local languages. Students involved in these programs often serve as climate ambassadors within their households and communities, spreading awareness and influencing behavioral change beyond the classroom.

2. Economic Incentives for Participation

1) Revenue Sharing: Revenue-sharing mechanisms can play a key role in fostering community trust and long-term engagement in methane mitigation efforts. One proposal is to allocate 10% of net profits from methane capture and reuse projects into a dedicated Community Development Fund (CDF). This model mirrors Alaska's oil dividend program, which distributes a portion of oil revenues directly to residents. In the Nigerian context, these funds could be used to finance essential services such as healthcare, school infrastructure, clean water access, or local business development [79]-[81]. To promote transparency, CDFs should be governed by multi-stakeholder boards including community representatives, traditional leaders, and local government officials. Revenue streams can come from flare-to-energy sales, carbon credit trading, or biogas cooperatives. Pilot schemes in oil-producing communities like Ogulagha or Kula can test this approach. Linking methane reduction to direct, visible community benefits reinforces public buy-in and reduces resistance to infrastructure expansion or regulatory enforcement.

2) Job Creation: Methane mitigation can provide employment opportunities for local residents if jobs are deliberately structured to support inclusive hiring. Priority should be given to training and recruiting locals for roles in leak detection, equipment maintenance, biogas system management, and flare-to-energy conversion. Partnerships with technical colleges, local NGOs, and global partners like the Climate and Clean Air Coalition (CCAC) can provide tailored vocational training. Skill development modules could include satellite image interpretation, infrared camera operation, and data entry for emissions reporting systems. These programs can be adapted to both literate and semi-literate populations, ensuring wider participation. Hiring targets and job quotas can be included in project funding agreements to ensure implementation. Beyond technical jobs, indirect employment in transportation, catering, and communication services can also emerge. These jobs not only reduce local unemployment but also create a sense of ownership over environmental outcomes, making long-term methane control more feasible and sustainable.

3. Governance and Implementation Framework

An efficient governance and implementation framework for community-based methane monitoring in the Niger Delta should involve joint oversight by community leaders, regulators, and oil company representatives to ensure transparency and accountability. Legal backing can be provided through a proposed "Commu-

nity Monitoring Rights” clause in the Petroleum Industry Act, while sustainable funding may come from allocating 5% of oil companies’ corporate social responsibility budgets to surveillance and training. The Ogoni Land initiative (2022-2024) offers a proven model, having trained 62 teams, averted 317 leaks, and engaged 14 local contractors for repair works demonstrating the potential for environmental protection and economic empowerment. Implementation should follow a phased approach: a 2025-2026 pilot in Bayelsa, Rivers, and Delta states using existing NiMERP infrastructure, followed by national scale-up (2027-2030) aligned with Nigeria’s Global Methane Pledge. Key partnerships with MethaneSpotter (app localization), Federal University Otuoke and Niger Delta University (training), and NUPRC (policy enforcement) will support successful rollout.

14. Significance Statement

The significance of reducing methane emissions in Nigeria, particularly in the Niger Delta, extends beyond local communities to global climate change efforts. Methane is a powerful greenhouse gas that significantly contributes to global warming. Addressing emissions in the Niger Delta is essential for implementing effective strategies that target this issue within a broader context. Focusing on this region allows for the development of targeted interventions that not only enhance local environmental quality but also align with global climate objectives. Additionally, reducing methane emissions in the Niger Delta is vital for improving public health and promoting environmental justice. High methane levels, coupled with related pollutants, can lead to respiratory problems and impact the overall quality of life for local residents. Engaging communities and investing in cleaner technologies can foster healthier living conditions while supporting global climate mitigation initiatives. This integrated approach highlights the importance of prioritizing both environmental sustainability and public health within the institutional framework for methane emissions reduction in Nigeria. Thus, graphically it is represented (Figure 5 and Figure 6) as:

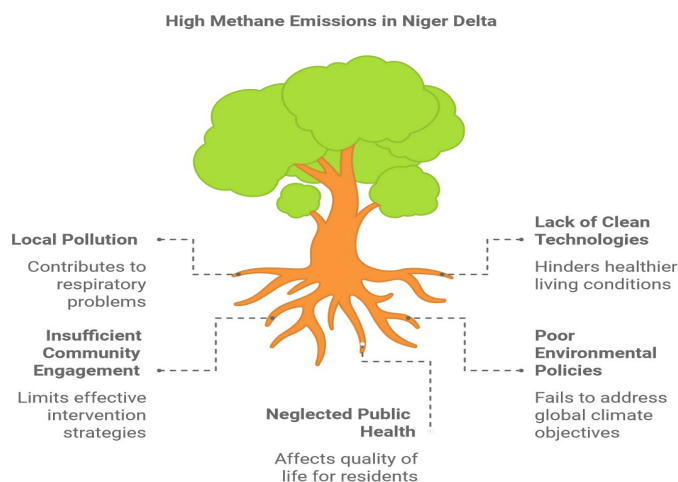


Figure 5. High methane emission in the Niger delta.

Reduce methane emissions for healthier communities and global climate.

High methane emissions impact health and environment

Local residents suffer.

Achieve cleaner air and sustainable practices

Enhance quality of life.



Figure 6. Reduce methane emission for healthier communities and global climate.

15. Conclusion

In conclusion, Nigeria faces major challenges in reducing methane emissions, especially in the Niger Delta, where oil and gas extraction is a primary source. Gaps in emissions data and limited monitoring highlight the need for a stronger institutional framework. Collaboration among government agencies, research institutions, and funding organizations is essential to enforce reductions and improve transparency. Insights from the NiMERP program provide a detailed understanding of methane emissions across key sectors, forming the basis for targeted mitigation efforts. Given methane's high global warming potential, reducing emissions is both a national priority and a global responsibility. Advanced monitoring technologies and community engagement can enhance mitigation while benefiting public health and the environment. National and global policy commitments must set clear targets and ensure accountability. Success will depend on collaboration between national stakeholders and international partners, along with integrating technologies like UAVs, infrared cameras, and satellites for accurate tracking. Addressing methane emissions in the Niger Delta will support climate goals and improve sustainability. Nigeria's progress can serve as a model for other countries in the Global South, reinforcing its role in global climate efforts.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

List of abbreviations.

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| CCAC | Climate and Clean Air Coalition |
| COP26 | 26th Conference of the Parties (United Nations Climate Change Conference) |
| GMP | Global Methane Pledge |
| IEA | International Energy Agency |
| NDC | Nationally Determined Contributions |