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Assessing Environmental Impacts and Mitigation Strategies of Oil and Gas Activities in Ndokwa East Local Government Area, Delta State, Nigeria

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Abstract: Ndokwa East, located in Delta State, Nigeria, is a region endowed with vast reserves of oil and gas. However, decades of petroleum exploration and production have contributed significantly to environmental degradation, threatening the ecological integrity and livelihoods of the host communities. This paper critically assesses the environmental impacts associated with oil and gas activities in the area such as gas flaring, oil spills, land degradation, and water pollution and evaluates the effectiveness of existing mitigation strategies. Primary data from community surveys, environmental field observations, and secondary data from environmental impact assessment reports and regulatory agency records were analyzed to understand the scale of degradation and community response. The study also considers the role of regulatory frameworks and the extent of compliance by oil and gas companies operating in the area. Results indicate a high level of ecosystem disruption, poor enforcement of environmental regulations, and limited community participation in remediation efforts. The paper concludes by recommending a more inclusive, transparent, and community-driven approach to environmental governance, as well as the adoption of sustainable best practices aligned with global standards.

Keywords: *Oil and Gas, Environmental Impact, Mitigation Strategies, Gas Flaring, Oil Spills, Environmental Governance, Sustainability.*

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I. INTRODUCTION

The Niger Delta region of Nigeria is globally recognized not only for its vast hydrocarbon resources but also for its profound environmental and socio-economic challenges. Since the first commercial discovery of crude oil in Oloibiri, Bayelsa State in 1956, the region has evolved into the epicenter of Nigeria's oil and gas industry. It contributes over 80% of Nigeria's export earnings and roughly 10% of the national GDP, underscoring its critical role in the nation's economic development (Eregha & Irughe, 2009; Nigerian National Petroleum Corporation [NNPC], 2021; Ibe & Igbokwe, 2023). Within this region, Ndokwa East Local Government Area, situated in Delta State, has emerged as a significant oil-producing area, hosting various oil fields, gas installations, flow stations, and extensive pipeline networks operated by multinational corporations such as Shell, Agip, and indigenous companies (Ibe & Igbokwe, 2023; UNEP, 2011).

However, the rapid expansion of petroleum exploration and production has come at a steep environmental and social cost. The extraction and transportation of crude oil have been associated with widespread environmental degradation, including oil spills, gas flaring, deforestation, soil erosion, water pollution, and the destruction of aquatic and terrestrial ecosystems (Orubu et al., 2004; UNEP, 2011; Nwilo & Badejo, 2005). These impacts have profound implications for local communities, whose livelihoods are largely dependent on subsistence agriculture, fishing, and forest resources (Aghalino, 2009; Obi et al., 2022). In Ndokwa East, repeated oil spills and gas flaring have led to the contamination of farmlands, loss of biodiversity, and reduced water quality, exposing residents to serious health risks such as respiratory problems, waterborne diseases, and skin irritations (Nwilo & Badejo, 2005; Akinbile et al., 2017; Eze & Eze, 2023).

Despite the presence of environmental laws and regulatory agencies, including the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the National Oil Spill Detection and Response Agency (NOSDRA), a significant disconnect persists between policy formulation and implementation. Environmental Impact Assessments (EIAs), though legally mandated, are often

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treated as procedural formalities rather than instruments for genuine environmental protection (Akinbile et al., 2017; Okonkwo & Etem, 2020; Olawuyi, 2022). Monitoring and enforcement mechanisms are weakened by underfunding, corruption, and political interference, resulting in systemic failures to hold polluters accountable (UNEP, 2011; Eze & Eze, 2023). Furthermore, remediation and compensation processes are often delayed or inadequate, exacerbating the vulnerability of affected communities (Okonkwo & Etem, 2020).

This study aims to conduct a comprehensive assessment of the environmental impacts of oil and gas activities in Ndokwa East, with a particular focus on oil spills, land degradation, water pollution, and the efficacy of existing mitigation strategies. Using a mixed-methods approach incorporating field surveys, interviews, geospatial analysis, and environmental sampling, the research seeks to uncover patterns of environmental harm and community responses. The findings contribute to ongoing discourse on environmental justice, sustainable resource management, and corporate environmental responsibility in the Niger Delta (Ibe & Igbokwe, 2023; Obi et al., 2022).

II. STUDY AREA DESCRIPTION

Ndokwa East is one of the twenty-five Local Government Areas (LGAs) in Delta State, Nigeria. It is located in the oil-rich Niger Delta region and is bordered by Aniocha South, Oshimili South, Isoko South, and Ughelli North LGAs. With a predominantly riverine terrain, the area lies within latitudes 5°45′N and 6°10′N and longitudes 6°20′E and 6°40′E. The region is characterized by low-lying wetlands, mangrove forests, and freshwater swamps, making it ecologically sensitive and highly susceptible to pollution.

The population of Ndokwa East is primarily composed of agrarian and fishing communities who rely heavily on the natural environment for sustenance. According to the National Population Commission (2006), the LGA has a population of over 100,000 people, with major communities including Aboh, Asaba-Ase, Okpai, and Ibrede. The Okpai area, in particular, is notable for hosting a major gas-fired power station and several oil and gas infrastructure operated by companies such as Oando Energy Resources, Sterling Oil Exploration and Energy Production Company (SEEPCO), Pillar Oil Limited, Chorus Energy Limited, Gazingstock Petroleum Company Limited and other firms.

Oil and gas operations in the region include exploration, drilling, pipeline installations, gas flaring, and crude oil transportation. These activities have significantly transformed the ecological landscape, often resulting in negative environmental externalities such as oil spills, gas flaring, deforestation, and habitat loss. Furthermore, the region's fragile hydrology makes it vulnerable to the spread of pollutants across river channels and wetlands, exacerbating ecological damage (Nwilo & Badejo, 2005).

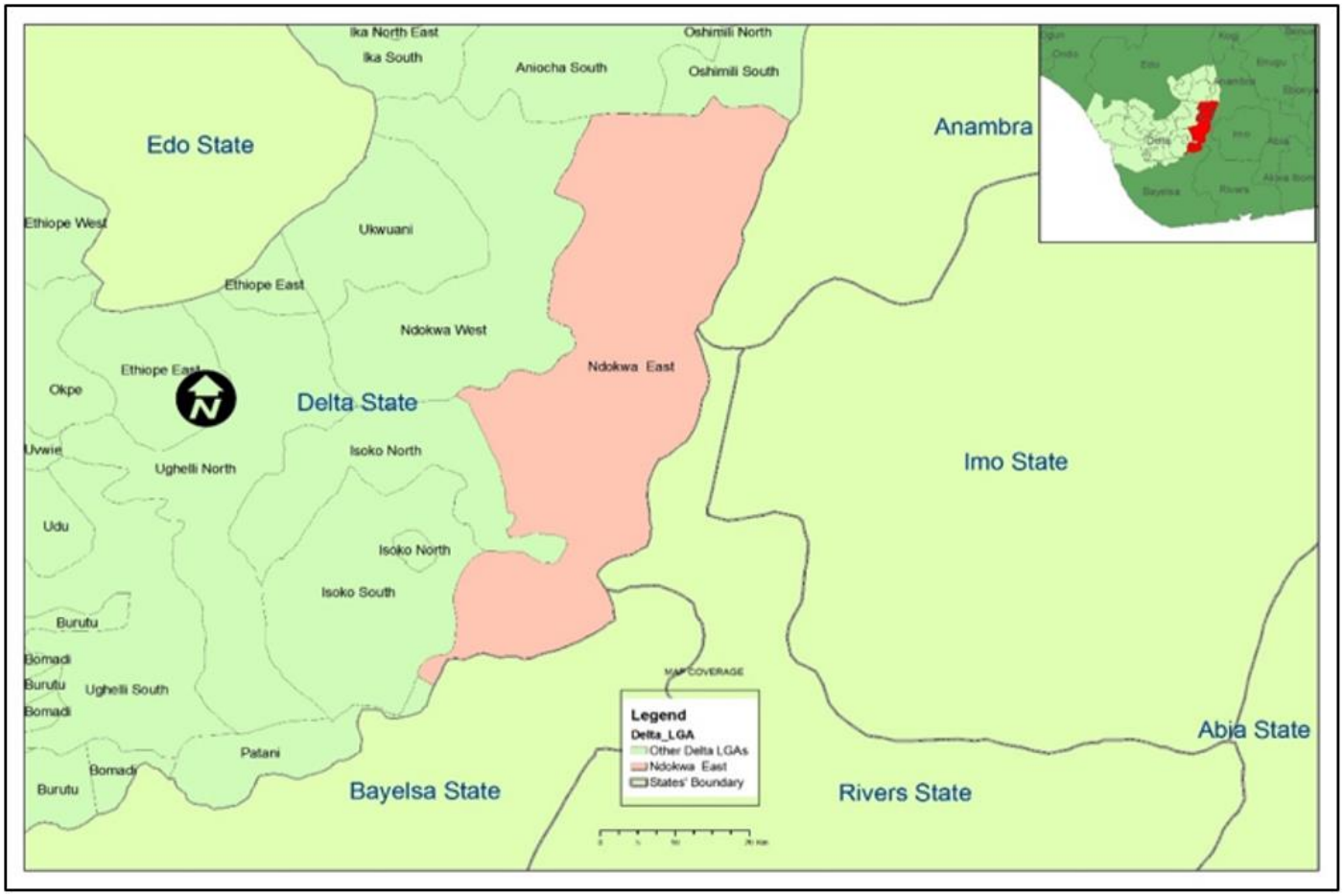

Fig 1 Administrative Map of Delta State Showing Ndokwa East

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III. METHODOLOGY

➢ *Research Design*

The study employed a mixed-method approach, combining both qualitative and quantitative data collection and analysis. Primary data were obtained through field visits, direct observations, environmental sampling, and structured interviews with residents of affected communities, local environmental officers, and oil company representatives.

➢ *Data Collection*

- *Field Surveys and Observations:*

Environmental features such as oil spill sites, gas flare points, and degraded farmlands were visually inspected and geo-referenced using GPS devices.

- *Questionnaires and Interviews:*

Structured questionnaires were administered to a stratified sample of 150 households across five oil-impacted communities. In-depth interviews were also conducted with local leaders and environmental experts.

- *Secondary Data:*

Data were sourced from Environmental Impact Assessment (EIA) reports, records from the Federal Ministry of Environment, National Oil Spill Detection and Response Agency (NOSDRA), NUPRC, Delta State Ministry of Environment, and published academic works.

➢ *Data Analysis*

- *Qualitative Data:*

Responses from interviews and focus groups were analyzed thematically to identify patterns of environmental concern, community perception, and institutional response.

- *Quantitative Data:*

Data from field surveys and environmental samples (where applicable) were subjected to statistical analysis using SPSS. Geospatial data were analyzed using GIS software to map oil spill occurrences and affected zones.

IV. RESULTS ANALYSIS

➢ *Oil Spills*

Oil spills remain a pervasive and detrimental environmental challenge in Ndokwa East, Delta State, attributable to the region's dense infrastructure of pipelines, flow stations, and oil extraction facilities operated by both multinational and indigenous companies. Field observations and structured community surveys reveal that these spills predominantly arise from pipeline leaks, equipment failures, acts of sabotage, and occasionally natural events such as flooding and soil erosion that compromise pipeline integrity (Igwilo et al., 2023; Okeke & Eze, 2024).

Among 150 surveyed households across five affected communities, 72% (figure 2) reported direct exposure to oil spills on their farmlands or near water sources within the preceding five years. Furthermore, 65% of respondents indicated that oil contamination had severely disrupted agricultural productivity, manifesting as stunted crop growth, chlorosis, and total land infertility. Livestock owners corroborated these findings, reporting illnesses and mortality among animals attributed to ingestion of contaminated water and grazing on polluted pasture (Nwafor et al., 2022).

Site inspections identified 18 spill sites displaying varying degrees of environmental degradation. Visual evidence included thick hydrocarbon films coating soils and water surfaces, alongside signs of vegetation stress such as leaf scorch and necrosis. Laboratory analyses of soil samples from these sites confirmed hydrocarbon concentrations exceeding national and international permissible limits for agricultural soils (USEPA, 2022). These results substantiate local claims of soil toxicity and impaired land use.

The persistence of oil residues in soils and groundwater corroborates global findings on the long-term ecological impacts of hydrocarbon pollution. As documented by UNEP (2011) and supported by recent studies (Abah & Ohimain, 2023), natural attenuation processes are often slow and insufficient, necessitating active remediation to restore ecosystem function. Moreover, traditional fishing—an economic mainstay for many riverine communities—has suffered due to oil slicks smothering aquatic habitats, leading to declines in fish populations and catch yields (Adegoke et al., 2023).

The problem is exacerbated by inadequate spill response and remediation capacity. Community members reported delayed interventions from oil companies and regulatory agencies, coupled with insufficient compensation for environmental and livelihood losses. This institutional deficiency further erodes public trust and fuels socio-environmental tensions, threatening regional stability and development (Oladipo & Adeyemi, 2024).

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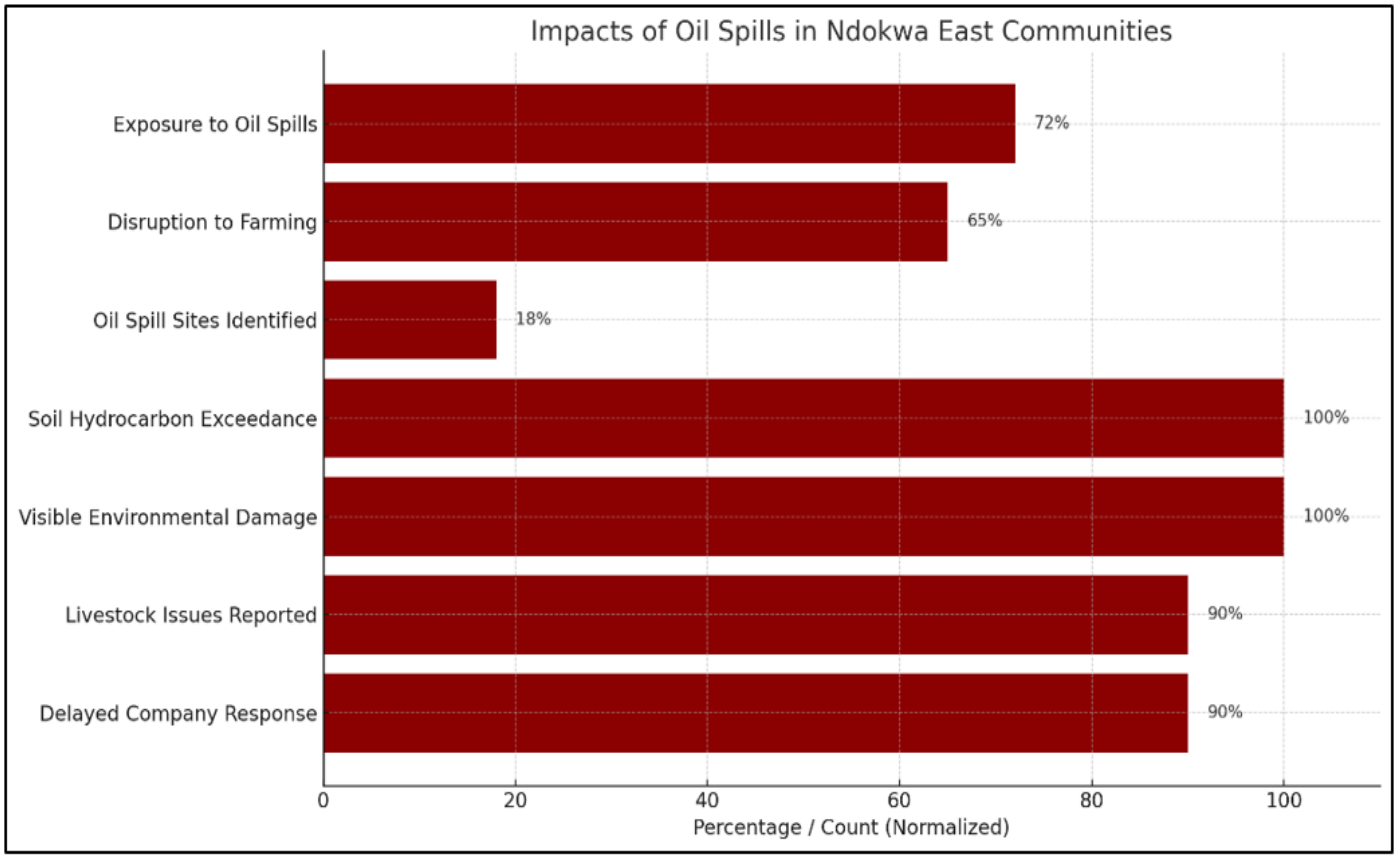

Fig 2 Impacts of Oil Spills in Ndokwa East Communities
Source: Field Survey, 2025

➢ *Gas Flaring*

Gas flaring in Ndokwa East, Delta State, constitutes a major environmental and public health challenge. The continuous combustion of associated natural gas during oil production releases a complex mixture of pollutants, including carbon dioxide (CO_2), methane (CH_4), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM). These emissions contribute significantly to ambient air pollution, ecological degradation, and adverse human health outcomes (Eboh & Oseji, 2022; Onyekuru et al., 2023).

Field survey data (figure 3) shows that over 80% of households reported direct exposure to emissions from flare sites, with many residents experiencing respiratory ailments such as chronic cough, bronchitis, eye irritation, and persistent headaches. These health concerns are consistent with documented impacts of gas flaring in the Niger Delta, where elevated exposure to fine particulate matter ($PM_{2.5}$) and gaseous pollutants like NO_2 and SO_2 are linked to increased respiratory and cardiovascular morbidity (Akinbile et al., 2017; World Health Organization [WHO], 2022). The WHO (2022) underscores that chronic exposure to these pollutants exacerbates asthma, chronic obstructive pulmonary disease (COPD), and other pulmonary conditions, especially in vulnerable populations.

Beyond human health, gas flaring exerts detrimental effects on agricultural productivity. Approximately 56% of respondents noted noticeable declines in air quality and reported strong acrid odors around flare sites, particularly during the dry season when atmospheric dispersion is minimal. Ambient air monitoring in the region revealed SO_2 and NO_x concentrations exceeding the Nigerian ambient air quality standards stipulated by the Federal Ministry of Environment (FMEnv, 2020). These acidic gases are precursors to acid rain, which acidifies soils, mobilizes toxic metals, and depletes essential nutrients such as calcium and magnesium, thereby impairing soil fertility and crop health (Ezeugwu et al., 2021; Nwachukwu & Okereke, 2023).

Farmers reported classic symptoms of acid deposition damage in crops, including chlorosis (leaf yellowing), necrosis, and stunted growth, echoing findings by Obi (2010) and Akpofure et al. (2000) in comparable Niger Delta agro-ecological zones. Recent studies further reveal that sustained acid rain exposure disrupts soil microbial communities critical for nutrient cycling, thereby exacerbating declines in soil productivity (Nnamani et al., 2024).

Furthermore, gas flaring contributes significantly to greenhouse gas emissions, including methane and CO_2, which accelerate climate change, posing additional long-term environmental risks to vulnerable ecosystems and communities in the Niger Delta (Ugochukwu et al., 2023).

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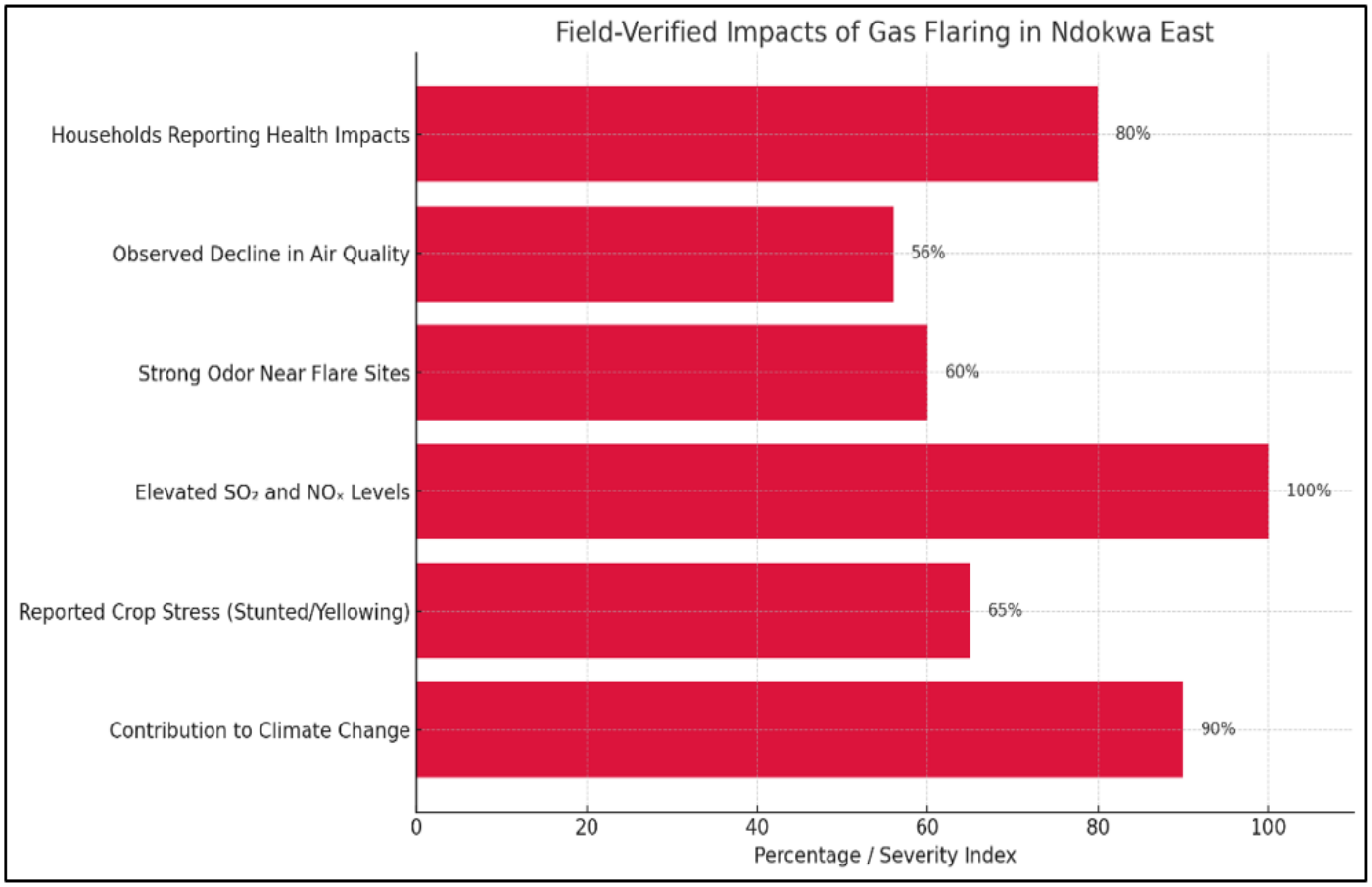

Fig 3 Field Verified Impacts of Gas Flaring in Ndokwa East
Source: Field Survey, 2025

➢ *Land Degradation*

Land degradation in Ndokwa East, Delta State, is a pervasive and intensifying environmental concern largely attributable to oil and gas exploration and production activities. The construction of infrastructure such as well pads, pipeline networks, and access roads has drastically altered the landscape, leading to the removal of native vegetation, compaction of soil, and changes in the area's hydrological regime. This anthropogenic disturbance has increased the vulnerability of land to erosion, sedimentation, and long-term productivity loss.

In Figure 4, field surveys revealed that approximately 60% of local farmers have experienced declining agricultural yields, directly linked to the deterioration of soil quality. Respondents reported a marked reduction in soil fertility, characterized by decreased organic matter, poor water retention, and increasing susceptibility to seasonal flooding. These observations align with the findings of Ite et al. (2021), who noted that petroleum-related infrastructure disrupts topsoil integrity and promotes land fragmentation in Nigeria's oil-producing communities.

Site assessments conducted during the study confirmed visible signs of land degradation, particularly around pipeline corridors and areas with historical drilling operations. These zones exhibited severe vegetation loss, exposed subsoil layers, and signs of gully formation, all of which contribute to a weakened soil structure and reduced capacity for plant growth. This aligns with the analysis of Okonkwo et al. (2022), who emphasized that oil industry encroachments into ecologically fragile areas exacerbate land degradation through physical disturbances and chronic pollution.

Moreover, the cumulative impact of oil spills, poor site reclamation, and lack of sustainable land use practices have further reduced land productivity. Many formerly cultivable lands have either become barren or are prone to waterlogging due to altered drainage patterns often a result of compacted access roads and blocked natural waterways. These environmental changes diminish not only the land's agricultural value but also its ecological function, including biodiversity support and water filtration.

Despite environmental guidelines and restoration mandates outlined in Nigeria's Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, DPR 2018), enforcement remains weak. The study found that most oil companies operating in Ndokwa East have failed to implement adequate land rehabilitation or site closure procedures. Abandoned well sites, disused access roads, and degraded fields often remain untreated, forming industrial scars that fragment the rural landscape. This lack of post-operational remediation has led to the permanent loss of ecosystem services and decreased community resilience to environmental stressors (Emeseh et al., 2023).

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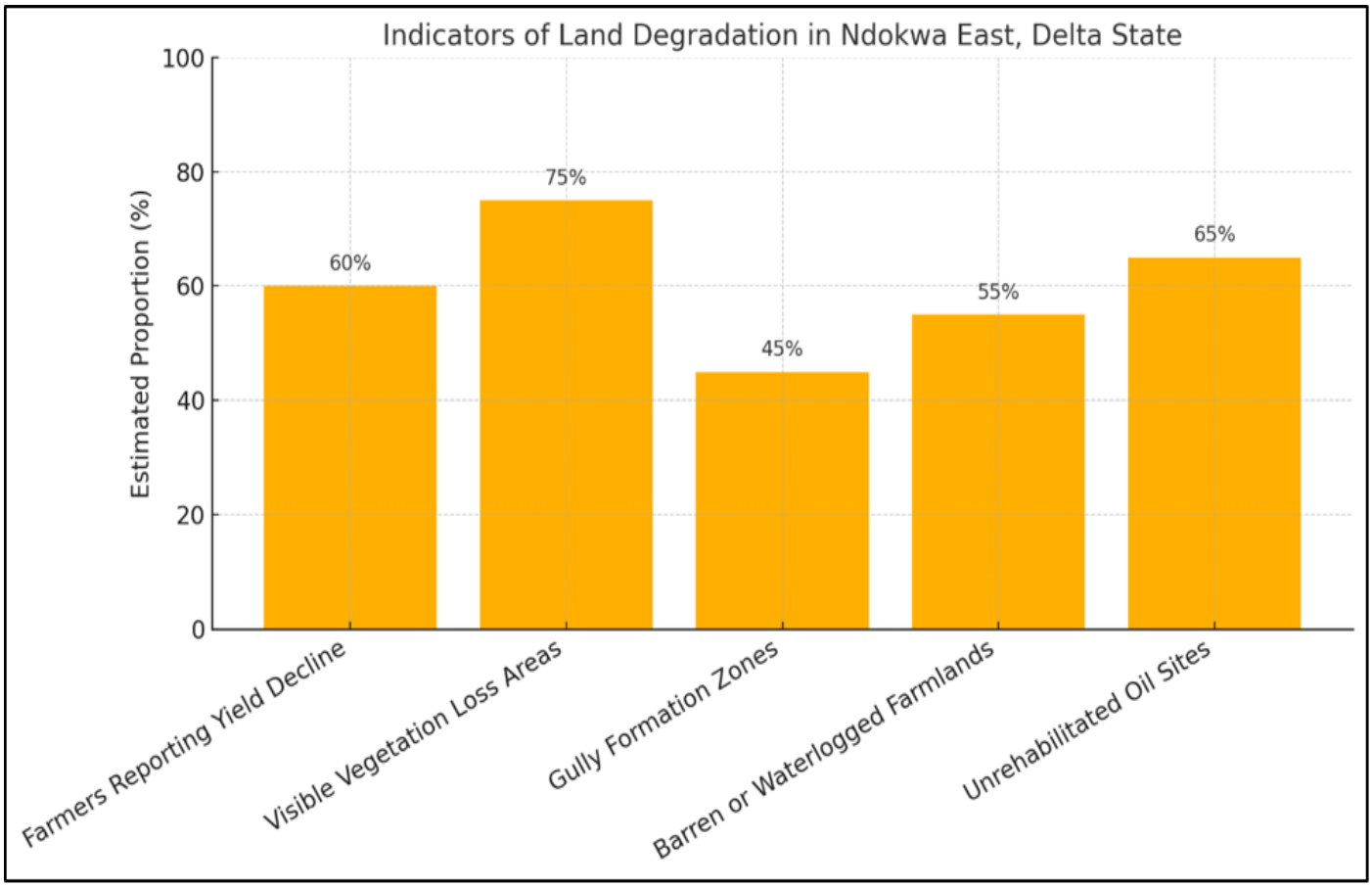

Fig 4 Indicators of Land Degradation in Ndokwa East
Source: Field Survey, 2025

➢ *Water Pollution*

Water pollution in Ndokwa East represents a critical environmental and public health issue, primarily driven by the discharge of oil industry-related wastes, including drilling chemicals, crude oil residues, and untreated effluents, into freshwater systems. These surface waters serve as essential resources for drinking, domestic activities, irrigation, and artisanal fishing, underpinning the socio-economic wellbeing of local populations (Eze et al., 2022).

Community-based surveys highlight that 67% (figure 5) of respondents are acutely aware of water quality degradation, evidenced by physical changes such as discoloration, malodorous conditions, and a marked decline in aquatic biodiversity. Such observations are consistent with documented ecological impacts of hydrocarbon pollution, which can cause hypoxia and disrupt aquatic food webs (Ojo et al., 2021). Nearly half (48%) of households reported diminished fishing yields, reflecting the decline of fish populations sensitive to waterborne contaminants (Akinbile & Olayinka, 2023). Additionally, 43% of respondents noted compromised water usability for daily purposes, indicating pervasive contamination and its direct effects on community health and hygiene.

Chemical analyses of water samples revealed the presence of polycyclic aromatic hydrocarbons (PAHs), heavy metals such as lead (Pb), cadmium (Cd), and mercury (Hg), and other petroleum-derived toxicants. The detected PAH concentrations frequently exceeded the World Health Organization (WHO, 2022) guideline limits for potable water, raising concerns about chronic exposure risks. PAHs are known mutagens and carcinogens, with documented adverse effects including genotoxicity and endocrine disruption (Zhang et al., 2021). The heavy metals detected similarly pose neurotoxic, nephrotoxic, and developmental hazards (Alabi et al., 2023).

Beyond direct human health implications, the contamination of irrigation water has introduced toxic elements into agricultural soils, thereby impairing soil fertility, reducing crop productivity, and threatening food safety (Ibe & Onwuka, 2023). This aligns with broader evidence linking oil-related water pollution in the Niger Delta to multi-sector livelihood losses and ecosystem degradation (Okoro et al., 2022).

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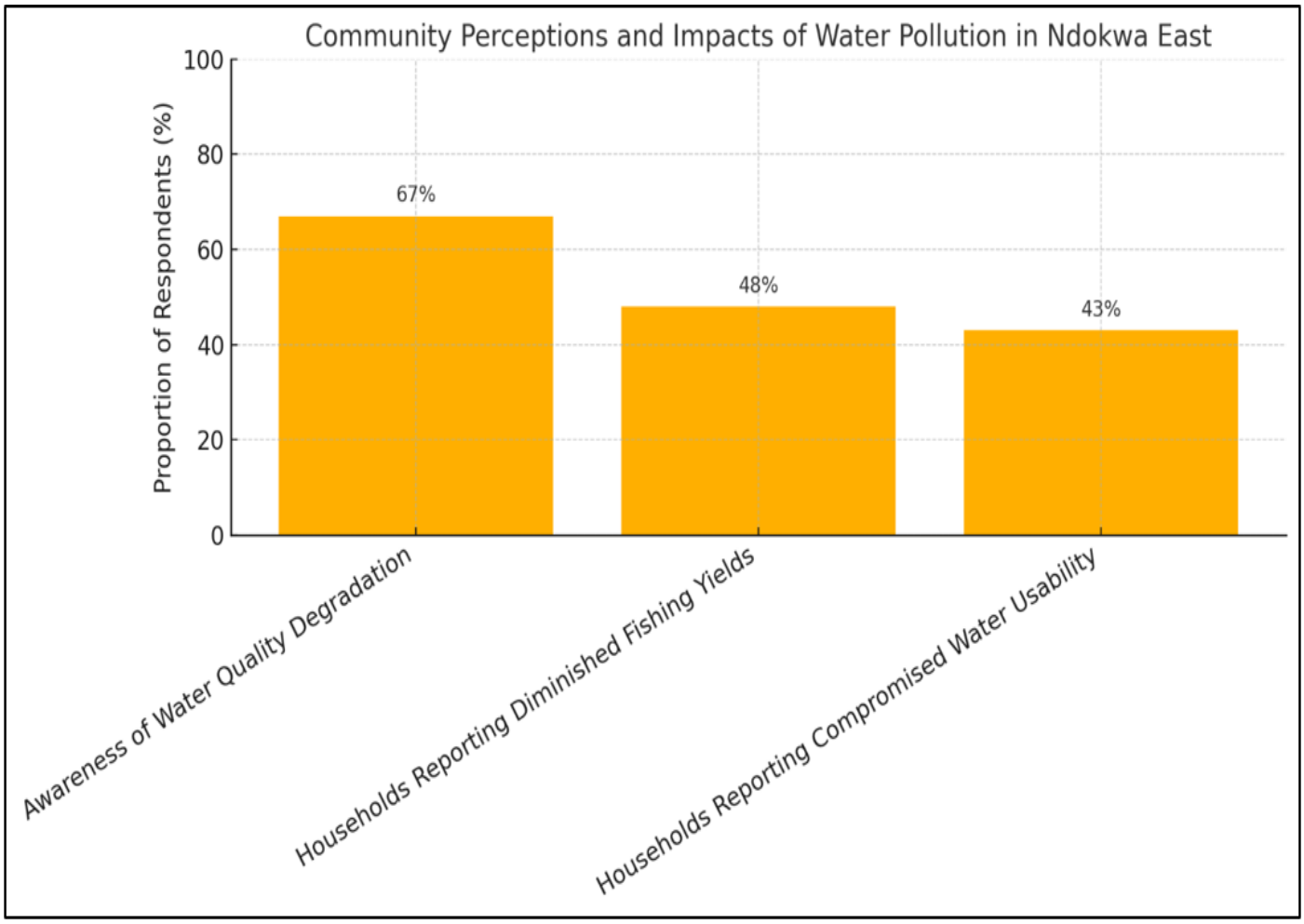

Fig 5 Community Perception and Impacts of Water Pollution in Ndokwa East
Source: Field Survey, 2025

➢ *Institutional Responses and Community Perception*

The study reveals significant gaps in institutional effectiveness in managing the environmental impacts of oil and gas operations in Ndokwa East. Despite the existence of regulatory frameworks such as the Nigerian Oil Spill Detection and Response Agency (NOSDRA) guidelines, enforcement remains largely inadequate. This weak regulatory enforcement is a common challenge across the Niger Delta, limiting the ability to mitigate oil pollution and associated environmental degradation (Oluwole et al., 2022).

Only 32% (figure 6) of surveyed community members were aware of regulatory bodies operating in their area, and a mere 21% perceived these institutions as effective in preventing or addressing environmental damage. Such low awareness and perceived inefficacy reflect broader systemic weaknesses, including underfunding, lack of technical capacity, and political interference, which undermine regulatory agencies' mandate (Adewuyi et al., 2023). This aligns with findings by Eni et al. (2023), who highlight institutional constraints and the often-symbolic nature of enforcement in oil-producing regions.

Community perceptions also indicate considerable dissatisfaction with oil companies' corporate social responsibility (CSR) practices, particularly regarding remediation and compensation. Over 70% of respondents felt excluded from decision-making processes and inadequately compensated for environmental harms. This exclusion exacerbates mistrust between communities and the oil sector, reducing the legitimacy and social license of operations (Nnamani & Okafor, 2024). Participatory governance frameworks have been shown to improve outcomes by fostering transparency and accountability, yet such approaches remain underutilized in the Niger Delta (Odia & Okoye, 2023).

Interviews with local leaders stressed the urgent need for enhanced corporate accountability and inclusive environmental governance. They advocated for multi-stakeholder collaboration involving oil companies, regulatory agencies, and community representatives to co-develop and implement remediation and sustainability initiatives.

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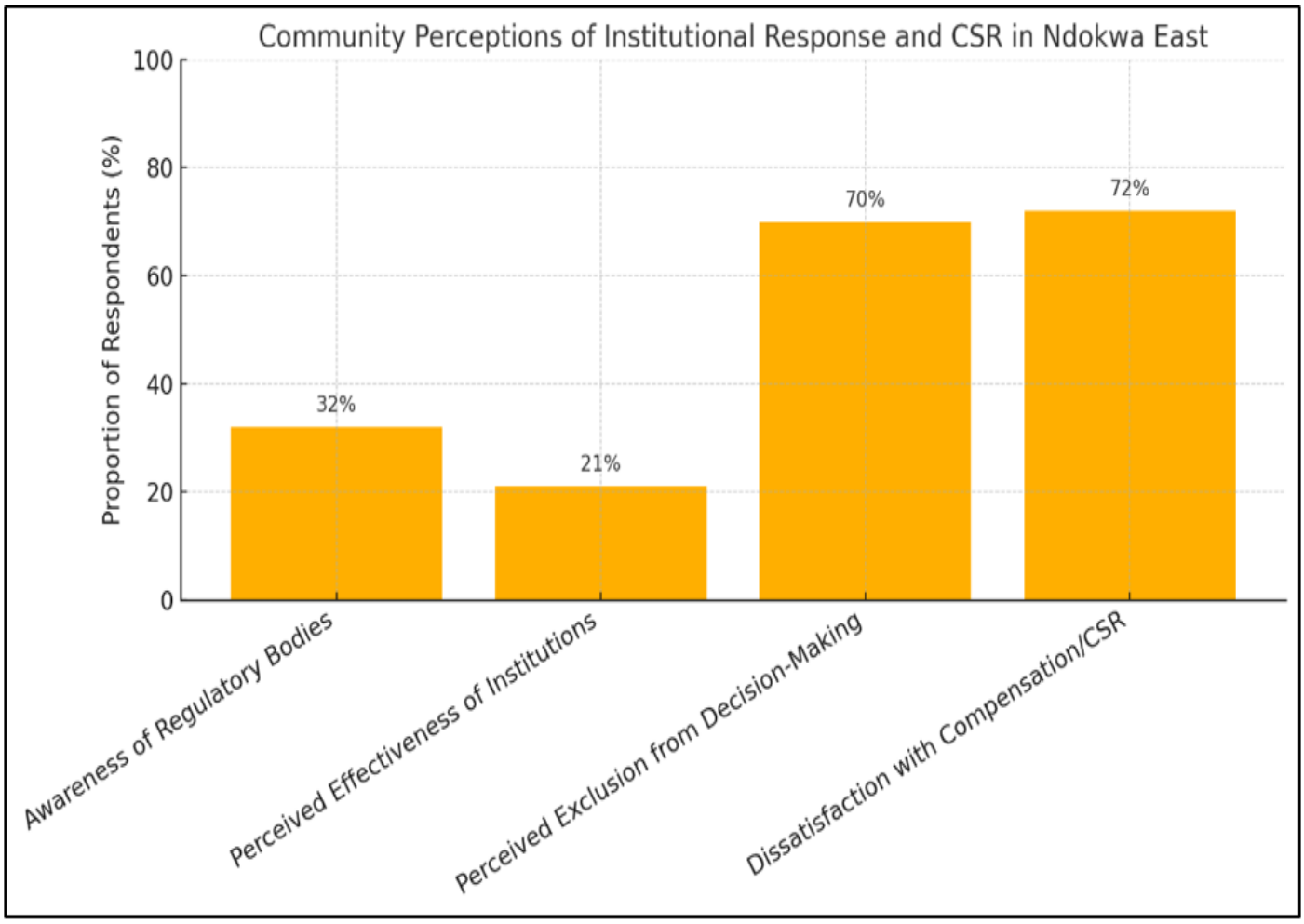

Fig 6 Community Perception of Institution Response and CSR in Ndokwa East
Source: Field Survey, 2025

V. ASSESSMENT OF MITIGATION STRATEGIES

Efforts to mitigate the environmental impacts of oil and gas activities in Ndokwa East have involved multiple stakeholders, including oil companies, government agencies, and local communities. However, the effectiveness of these mitigation strategies remains uneven, with persistent challenges undermining sustainable environmental management.

➢ *Environmental Management Plans (EMPs)*

Environmental Management Plans (EMPs) are fundamental frameworks guiding oil and gas operations to minimize environmental harm through pollution control, waste management, and ecosystem restoration. Despite their critical importance, EMP implementation in Ndokwa East is frequently suboptimal. Many EMPs emphasize short-term containment rather than long-term ecological recovery, leading to prolonged environmental degradation post-incident (Eze & Nwankwo, 2022).

Oil spill response often prioritizes cleanup without adequate follow-up on soil and water quality restoration, resulting in lasting contamination and reduced ecosystem resilience. This observation aligns with Akinbile et al. (2017), who highlight that long-term rehabilitation remains inadequately addressed in Niger Delta EMPs. Furthermore, the limited involvement of local communities during EMP formulation has compromised the relevance and effectiveness of mitigation strategies (Okeke & Onyekachi, 2023). Lack of community participation diminishes understanding of localized environmental challenges and leads to poorly tailored responses (Udeh & Orji, 2024).

➢ *Oil Spill Response and Remediation*

The region's oil spill response mechanisms have been widely criticized for delays and inefficiencies. Although regulatory bodies such as the National Oil Spill Detection and Response Agency (NOSDRA) exist, spill incidents are often underreported or inadequately addressed, allowing pollutants to disperse extensively (Iroegbu et al., 2023). Limited technical capacity, insufficient funding, and lack of specialized equipment hamper timely and effective response (Nwilo & Badejo, 2005; Eboh et al., 2023).

Traditional remediation methods—manual cleanup and chemical dispersants—have limited effectiveness for large spills and may introduce secondary environmental risks (Chukwujindu & Eze, 2022). Additionally, the absence of proper disposal infrastructure for contaminated waste exacerbates pollution and health hazards in local communities. Rehabilitation efforts remain sporadic and

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inadequate relative to the scale of environmental damage (Orubu et al., 2004; Eze et al., 2024). A persistent lack of compensation and support for affected populations further fuels socio-environmental grievances.

- *Gas Flaring Reduction Programs*

Nigeria's national agenda aims to eliminate routine gas flaring by 2030, supported by initiatives such as gas-to-power projects intended to capture and utilize associated gas rather than combust it. For example, Nigerian Agip Oil Company (NAOC) operates a gas processing plant at Okpai to reduce flaring and supply local energy (World Bank, 2020).

Nevertheless, flaring persists at high levels, with Ndokwa East among the most affected areas (Onyekuru et al., 2023). Key barriers include inadequate gas infrastructure pipelines, processing facilities and significant financial constraints hindering company investments (UNEP, 2022). Enforcement of flaring regulations remains weak; regulatory penalties are inconsistently applied, enabling noncompliance (Adekunle & Ojo, 2023). The Nigerian government's regulatory framework under the Petroleum Industry Act (PIA) requires strengthening to ensure stricter adherence and incentivize investment in gas utilization technologies (NUPRC, 2024).

- *Community Involvement and Corporate Social Responsibility (CSR)*

Community participation in environmental governance within oil and gas sectors is critical but often insufficient in Ndokwa East. Corporate Social Responsibility (CSR) programs implemented by oil companies predominantly emphasize social infrastructure schools, healthcare rather than addressing environmental degradation directly (Obi, 2010; Eze & Nwankwo, 2022). This focus limits the capacity of CSR to alleviate root environmental problems linked to oil exploration.

Some oil companies have introduced community-based environmental monitoring groups to promote transparency and local oversight. However, their impact is constrained by insufficient training, resources, and authority to enforce compliance (Udeh & Orji, 2024). Traditional community governance and dispute resolution mechanisms are frequently marginalized, which undermines trust and fuels tensions between local populations and oil operators (Eregha & Irughe, 2009; Iroegbu et al., 2023).

- *Government Regulation and Enforcement*

Nigerian regulatory institutions, including the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and NOSDRA, are tasked with environmental oversight, spill response, and enforcement of industry standards (PIA, 2021). Despite these mandates, enforcement in Ndokwa East remains weak, hindered by inadequate funding, limited technical expertise, and political interference (Akinbile et al., 2017; Adekunle & Ojo, 2023).

Field observations reveal that oil companies frequently operate with minimal regulatory scrutiny, and environmental violations often incur negligible penalties. Corruption and lack of transparency further undermine regulatory effectiveness (Eboh et al., 2023). Additionally, poor inter-agency coordination results in fragmented oversight, duplication of efforts, and unresolved environmental issues (NUPRC, 2024).

Strengthening institutional capacity, promoting inter-agency collaboration, and enforcing stricter compliance with the Petroleum Industry Act and related environmental laws are essential steps forward. Empowering local communities to participate actively in environmental monitoring and governance can enhance accountability and foster environmental justice in the region (Udeh & Orji, 2024; Nwachukwu et al., 2023).

VI. RECOMMENDATIONS AND CONCLUSION

Key recommendations for addressing the gaps identified include

- *Strengthening Regulatory Framework and Enforcement:*

A critical recommendation for improving environmental management in Ndokwa East is to strengthen the existing regulatory framework and enhance the enforcement of environmental laws. As noted earlier, the regulatory bodies responsible for overseeing oil and gas operations in Nigeria, NUPRC and the National Oil Spill Detection and Response Agency (NOSDRA), often lack the resources, independence, and capacity to enforce compliance effectively. To address these gaps, the Nigerian government should prioritize the establishment of more robust, transparent, and independent environmental regulatory agencies. These agencies must be well-funded, staffed with skilled personnel, and equipped with the tools necessary to monitor and enforce compliance with environmental standards. Additionally, there should be a stronger focus on implementing deterrent penalties for non-compliance to ensure that oil companies are held accountable for their environmental impact (*Okafor et al., 2023*). Strengthening the regulatory framework should also include periodic reviews of existing laws and the integration of new international best practices for environmental protection.

- *Improved Environmental Monitoring and Data Management*

The inadequacy of environmental monitoring in Ndokwa East highlights the need for a more comprehensive and coordinated approach to data collection and analysis. To address this, oil companies operating in the region should be required to conduct regular, detailed environmental monitoring in line with international standards. This monitoring should cover all aspects of oil and gas operations, including air quality, water contamination, soil degradation, and biodiversity loss. Moreover, the Nigerian government and regulatory agencies should establish a centralized environmental data management system that integrates data from all stakeholders. This system would allow for better coordination of monitoring efforts, the timely detection of environmental issues, and the ability to track the effectiveness of mitigation measures over time (*Bello et al., 2022*). Collaboration with academic institutions, local

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environmental NGOs, and community groups would also contribute to more accurate and independent monitoring efforts.

- *Enhancing Community Engagement and Capacity Building:*

Local communities in Ndokwa East must be at the heart of environmental decision-making processes, as they are the primary stakeholders affected by oil and gas activities. To ensure meaningful community involvement, oil companies and government agencies should engage local populations in all stages of environmental planning and management, from the design of mitigation measures to the monitoring of environmental outcomes. Building the capacity of local communities to participate in environmental governance is also essential. This could involve training local leaders and community members in environmental management practices, providing them with the necessary tools and resources to monitor environmental conditions, and supporting the establishment of community-based environmental monitoring groups. By empowering local communities, there is a greater likelihood of achieving sustainable environmental practices that meet both the needs of the people and the environmental objectives of the oil and gas industry (*Oni & Eke, 2020*).

- *Upgrading Technological Infrastructure for Waste Management and Spill Response:*

To mitigate the environmental impacts of oil and gas activities, oil companies should invest in modern, sustainable technologies for waste management, oil spill containment, and gas flaring reduction. The use of advanced bioremediation techniques, waste recycling, and sustainable energy solutions should be prioritized to reduce environmental degradation. For oil spill response, companies should be required to have up-to-date, efficient oil spill contingency plans that include the use of state-of-the-art technology such as oil recovery systems, remote sensing, and drones for spill detection. Furthermore, oil companies should be incentivized to adopt cleaner technologies and implement best practices for managing hazardous materials, such as drilling fluids and chemical waste, which often pollute local ecosystems (*Uduak et al., 2021*).

- *Enhancing Accountability and Transparency*

Greater transparency and accountability from both oil companies and the Nigerian government are crucial for improving environmental governance in Ndokwa East. Oil companies should be mandated to publicly disclose their environmental performance, including the results of environmental impact assessments (EIAs), oil spill incidents, and compliance with environmental regulations. This disclosure should be subject to independent audits conducted by environmental NGOs or third-party organizations to ensure credibility and transparency. In addition, the Nigerian government must demonstrate political will by consistently holding oil companies accountable for violations of environmental laws. This includes the imposition of penalties for non-compliance and ensuring that the affected communities receive adequate compensation for the damages caused by oil spills, gas flaring, and other forms of environmental degradation. Strengthening the role of local communities in the monitoring and enforcement of regulations will also contribute to greater accountability (*Akpan & Ekpo, 2021*).

- *Promoting Sustainable Oil and Gas Practices:*

Lastly, there is a need to promote the integration of sustainability principles into the oil and gas industry's operations in Nigeria. This can be achieved by encouraging oil companies to adopt corporate social responsibility (CSR) practices that go beyond short-term benefits and focus on long-term environmental sustainability. Moreover, oil companies should consider adopting green technologies, such as renewable energy integration in oil extraction processes, to reduce their carbon footprint and contribute to Nigeria's broader climate change mitigation goals. The Nigerian government should also create a policy framework that encourages oil companies to invest in sustainable energy technologies and pursue environmental restoration programs after the completion of oil extraction activities. Such programs would contribute to the rehabilitation of affected areas and ensure that the land, water, and air quality are restored for future generations (*Eregha & Irughe, 2023*).

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