

Black gold, empty plates: how oil and gas are destroying food security in the Niger delta

Abstract

Rationale: The Niger Delta, despite being Nigeria's oil-rich region, suffers from severe environmental degradation that threatens food production, community health, and economic stability. Oil spills, gas flaring, deforestation, and ineffective policy responses have transformed this once fertile area into one of the most ecologically and socioeconomically vulnerable zones in the country. This study addresses the pressing need for a comprehensive understanding of how environmental degradation exacerbates hunger and poverty.

Objectives: This study examines how oil-induced environmental degradation impacts land quality, agricultural productivity, and household food security in the Niger Delta. It assesses local perceptions, evaluates the effectiveness of government and corporate responses, and explores the use of predictive analytics to forecast poverty and food insecurity. Together, these objectives aim to inform targeted, data-driven policy interventions.

Methods: A narrative literature review was conducted, drawing from peer-reviewed Q1/Q2 journal articles, government and NGO reports, and international agency publications. Data from 2000–2024 were synthesized using thematic analysis to link oil-related environmental degradation to food production, poverty, and health indicators. Secondary data were complemented by spatial and perception-based insights.

Results: The study found that over 240,000 barrels of crude oil are spilled annually, causing large-scale land degradation and biodiversity loss. Cassava and yam production declined by 40% and over 50%, respectively, while fish catch dropped by two-thirds. Over 70% of Niger Delta residents live below the poverty line, and food insecurity affects most households. Local perceptions identified oil spills, gas flaring, and water pollution as primary drivers of hunger. Predictive analytics, when integrated with environmental and socioeconomic data, proved effective in identifying high-risk areas for targeted intervention.

Conclusion: Oil-induced environmental degradation is a key driver of hunger, poverty, and social unrest in the Niger Delta. While government and corporate interventions exist, they are often ineffective, poorly aligned with community needs, and marred by lack of transparency.

Recommendation: Policymakers should adopt an integrated response strategy that includes predictive poverty analytics, robust environmental governance, and community-led development planning. Strengthening data systems and aligning aid with local realities are essential for resilience building.

Significance Statement: This study provides a data-driven foundation for understanding the intertwined crises of environmental degradation, food insecurity, and poverty in the Niger Delta. It advocates for the innovative use of AI-enabled predictive tools to drive more effective, equitable, and forward-looking policy responses in ecologically fragile zones.

Keywords: food insecurity, environmental degradation, gas flaring, poverty prediction, agricultural decline, multidimensional poverty, predictive analytics, socioeconomic vulnerability, oil spills, Niger delta

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Bariweni Perekibina Anthony,¹ Oyibo Charles,² Morufu Olalekan Raimi³¹Department of Environmental Management and Pollution Control, Nigeria Maritime University, Nigeria²Department of Geography and Environmental Management, Faculty of Social Sciences, Niger Delta University, Nigeria³Niger Delta Institute for Emerging and Re-emerging Infectious Diseases (NDIERID), Federal University Otuoke, Nigeria**Correspondence:** Morufu Olalekan Raimi, Niger Delta Institute for Emerging and Re-emerging Infectious Diseases (NDIERID), Federal University Otuoke, Bayelsa State, Nigeria**Received:** May 25, 2026 | **Published:** June 19, 2026

Introduction

The Niger Delta, a linchpin of Nigeria's oil wealth, faces a paradox: despite contributing over 70% of the country's crude oil exports, its rural communities endure ecological destruction, agricultural collapse, and deepening hunger.^{1–13} Environmental degradation from oil spills, gas flaring, and land grabs has ravaged farmland, poisoned water sources, and disrupted traditional livelihoods.^{14–27} Figure 1 underscores this disparity, revealing that 63% of Nigerians suffer multidimensional poverty, with the highest intensity in oil-bearing communities.^{28–34} This crisis is not just regional, it threatens national food security, demanding urgent scrutiny from both policy and academic perspectives.^{35–37} Extensive studies confirm that oil-related

pollution directly undermines food production in the Niger Delta. Hydrocarbon contamination has rendered soil infertile and waterways toxic, decimating crops and fisheries.^{38–54} For instance, Babatunde and Adebayo⁵⁵ found that 68% of farmers in Delta and Bayelsa States reported yield losses exceeding 50% after oil spills. Similarly, Ogbekor and Aghoghovwia⁵⁶ estimated that gas flaring and spills have destroyed over 2,500 km² of arable land. These impacts are reflected in Figure 2, which show a strong correlation between environmental shocks and rising poverty. Table 1 further highlights poor nutrition and unsafe drinking water as top indicators of deprivation, reinforcing how pollution erodes both food security and public health. Despite this evidence, significant gaps hinder a full understanding of the crisis. Longitudinal data on how pollution perpetuates intergenerational

poverty or disrupts specific food systems remains scarce.^{57,58} For example, while Figures 3 depict declining school attendance in high-poverty areas, few studies explore how lost farming income affects children’s nutrition and education. Additionally, the compounding role of climate change in exacerbating oil-related damage is understudied.^{19,59–62} Without granular, time-series data linking spills to crop failures or nutritional losses as illustrated by the undifferentiated metrics in Figure 4 (panel A) and Table 1, interventions remain generic and ineffective. Filling these gaps is essential to shift from reactive to strategic policy-making. Current aid frameworks often fail to account for the spatial extent of farmland degradation or its ripple effects on food supply chains.^{11,63} This oversight is stark in Figure 4 (panel B), which shows Nigeria’s multidimensional poverty rate surging from 46.4% in 2020 to 62.9% in 2022, with food insecurity worsening disproportionately in the Delta. A deeper empirical grasp of these linkages such as the 41% drop in cassava yields documented by Babatunde¹¹ would enable targeted, locally informed solutions.

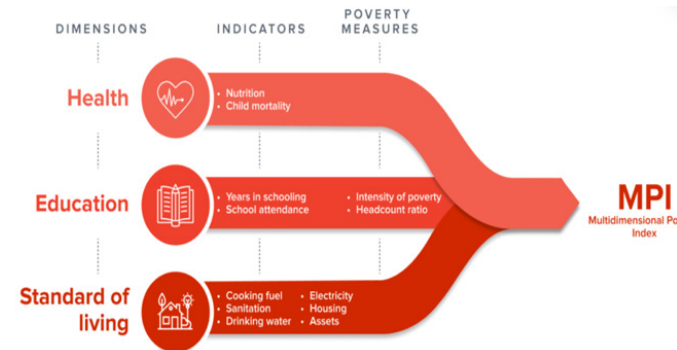


Figure 1 The three (3) dimensions and ten (10) indicators of Multidimensional Poverty globally.

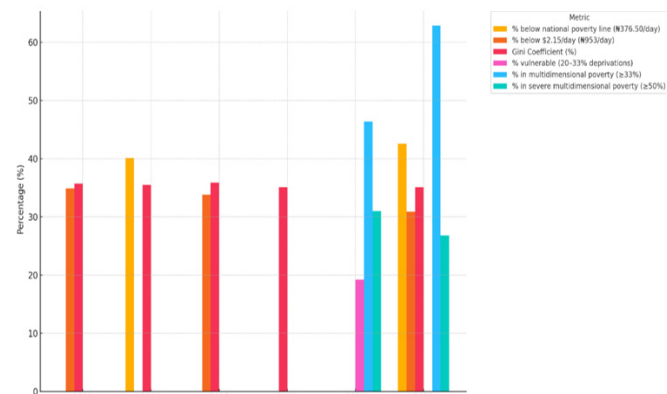


Figure 2 Comparison of Monetary Poverty, Multidimensional Poverty and Inequality (2010–2022).

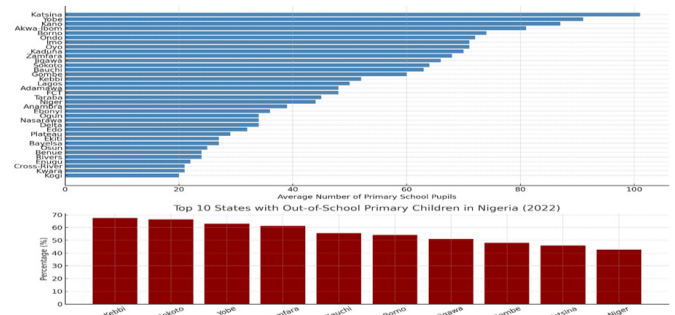


Figure 3 The figure presents a detailed analysis of primary education in Nigeria. The top section shows the average number of primary school pupils per state in 2018, providing insight into enrollment distribution across the country. The bottom section highlights the top 10 states with the highest percentage of out-of-school primary children in 2022, drawing attention to regions facing the most significant challenges in ensuring access to basic education.

Table 1 Multidimensional poverty indicators and deprivation cutoffs

Dimension	Indicator	Deprivation Cutoff	SDG Goal, Target or Indicator	Weight
Health	Nutrition	A household is deprived if any child under age 5 is undernourished (stunted/wasted) or any adult is underweight (BMI < 18.5).	2.2 / 3.2	12-Jan
	Food Insecurity	Household is severely food insecure per Food Insecurity Experience Scale (FIES): 2+ affirmative answers.	2.1.2	12-Jan
	Time to Healthcare	Deprived if it takes more than 30 minutes to reach nearest health facility (walking or local transport).	3.8.1	12-Jan
Education	School Attendance	Deprived if any child (6–14 years) is not attending school.	4.1 / 3.2	12-Mar
	Years of Schooling	No household member 10+ years has completed at least six years of schooling.	4.6	8-Jan
	School Lag	Deprived if any child (7–14 years) is 2+ years behind expected grade level.	4.1.1	12-Mar
Living Standards	Water	No access to safe drinking water (SDG definition) or takes 30+ minutes round trip to fetch water.	6.1	24-Jan
	Water Reliability	Water source not available ≥ 2 days in past 2 weeks.	6.1	24-Jan
	Sanitation	Household uses unimproved sanitation (shared facility or open defecation).	6.2	24-Jan
	Housing Materials	House has natural/dung/mud floor or walls.	11.1.1	24-Jan
	Cooking Fuel	Household uses wood, dung, or charcoal as cooking fuel.	7.1.2	24-Jan
Work & Shocks	Assets	Fewer than two assets (radio, TV, phone, bike, fridge, etc.)	—	24-Jan
	Unemployment	Deprived if any working-age member is unemployed and seeking work.	8.5.2	20-Jan
	Underemployment	Deprived if working-age member wants more hours but can't find them.	8.5.2	20-Jan
	Security Shock	Deprived if any member experienced a security shock (violence/theft/displacement) in the past 12 months.	16.1 / 13.4	20-Jan

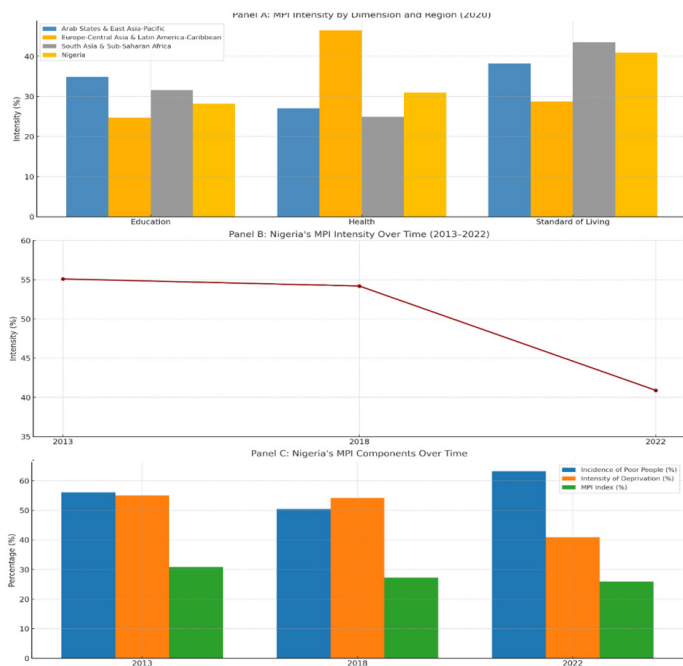


Figure 4 Multidimensional poverty in Nigeria: global comparisons and temporal trends (2013–2022).

Panel A compares the MPI intensity across the three key dimensions—Education, Health, and Standard of Living—between Nigeria and major world regions, avoiding data repetition to provide a clear comparative perspective. Panel B presents a trend line illustrating Nigeria’s MPI Intensity from 2013 to 2022, showing how the average severity of deprivation among the poor has evolved over time. Panel C uses grouped bar charts to display Nigeria’s key MPI components over the same period, including the Incidence of Poor People (the proportion of the population who are multidimensionally poor), the Intensity of Deprivation (the average share of deprivations experienced by the poor), and the overall MPI Index, enabling a comprehensive view of changes in multidimensional poverty in Nigeria across these years.

While, the crisis hits rural women, children, and smallholder farmers hardest. In communities like Bille, Andoni, and Ogoniland, contaminated waterways have forced abandonment of fishing, while soil acidification from gas flaring stunts crop growth.^{7,38,50,64,65} Women and children bear the brunt, facing malnutrition and health crises due to dwindling food access.^{5,55,66,67} Figure 4 (panel C) and Figure 5 starkly depict this nutritional deprivation, underscoring the need for interventions tailored to these marginalized groups. To break this cycle, research must prioritize localized, real-time data linking pollution to food metrics. Existing studies, such as those quantifying crop yield declines near flaring sites,^{7,27,68,69} provide a foundation, but dynamic, community-level insights are lacking. By integrating spatial trends, climate variables, and socio-economic feedback loops, as suggested by the gaps in Figures 4 and Figure 6, policymakers can design interventions that address both environmental harm and its cascading impacts on hunger. Only then can the Niger Delta transition from a symbol of resource curse to one of resilience.

Thus, to systematically address these challenges, this study pursues six key objectives: to evaluate the extent of land degradation due to oil exploration and its implications for arable land availability in the Niger Delta; assess the trend in agricultural productivity in relation to oil pollution events; analyze how oil-induced environmental degradation affects household food security and livelihoods, particularly in high-deprivation zones; examine local perceptions of hunger and food

scarcity linked to environmental changes; investigate government and oil company response mechanisms, assessing why existing mitigation efforts such as cleanup initiatives fail to curb food insecurity and explore how predictive poverty analytics can be integrated with environmental degradation data to forecast food insecurity and socioeconomic vulnerability in oil-impacted communities of the Niger Delta. By integrating these objectives, this research aims to bridge the gap between fragmented evidence and actionable policy. For instance, linking spatial pollution data with crop yield metrics could reveal priority areas for restoration, while community feedback could refine aid targeting. Only through such granular, evidence-based approaches can the Niger Delta transition from a symbol of resource curse to one of resilience.

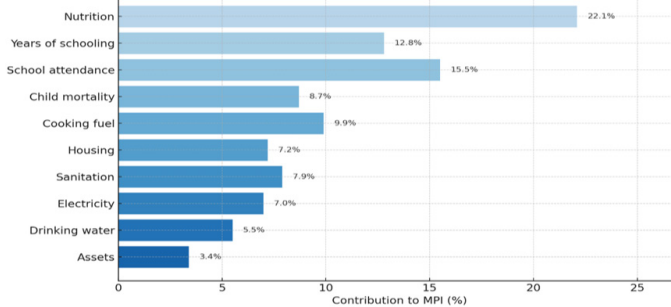


Figure 5 Breakdown of Nigeria’s Multidimensional Poverty Index (MPI). Nigeria has the highest subset of its population (22.1%) grappling with nutritional deficiencies, which reflect in stunting in children and low body mass index in adults.

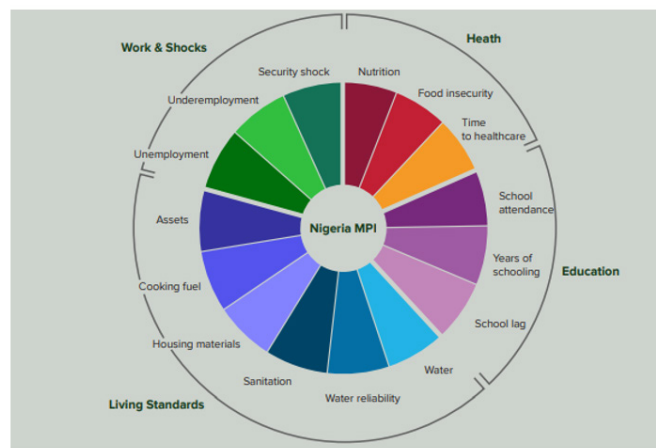


Figure 6 The Nigeria MPI (2022) also has a linked Child MPI. This Child MPI extends the Nigeria MPI to include appropriate indicators for children under 5, by adding a fifth dimension of child survival and development. This additional dimension contains eight vital aspects of early childhood development in physical and cognitive domains including severe undernutrition, immunization, intellectually stimulating activities, and preschool.

Methodology

This review adopts a narrative methodology aimed at synthesizing and interpreting existing research and data on how environmental degradation from oil and gas activities affects food production and security in the Niger Delta. The review was structured around the following key components: scope definition, data sources, inclusion criteria, search strategy, data extraction, and synthesis approach. The goal is to organize, evaluate, and explain findings across multiple disciplines including environmental science, public health, agriculture, and policy without statistical meta-analysis.

Scope of the review

The review focuses on empirical and policy-oriented studies published between 2000 and 2024, with a particular emphasis on recent high impact journal articles. Thematic areas include oil and gas pollution, soil and water contamination, food crop yields, fishing economy decline, community livelihoods, hunger indicators, and policy response. Geographically, the scope is limited to Nigeria's Niger Delta region, including key oil-producing states such as Bayelsa, Rivers, Delta, Akwa Ibom, Edo and Ondo.

Sources of data

Sources included peer-reviewed journal articles, government and NGO reports, academic databases (e.g., Scopus, Web of Science, ScienceDirect), and grey literature relevant to the Niger Delta. Emphasis was placed on high-quality, peer-reviewed articles indexed in databases like Scopus, SSRN, DOAJ, SpringerLink, and Wiley Online Library. Government documents from Nigeria's Ministry of Environment and NDDC reports, alongside publications from the UNDP, UNEP, and FAO was also referenced.

Inclusion and exclusion criteria

The following criteria sources were included:

- 1) Published in English between 2000 and 2024
- 2) Focused on oil-related environmental degradation in Nigeria
- 3) Provided data or conceptual frameworks linking pollution to food insecurity
- 4) Were published in high impact journals, or by authoritative global bodies (e.g., UNEP, FAO)

Opinion pieces were excluded, unverified blog articles, or studies with no clear link to environmental or food security data in the Niger Delta.

Search strategy

A structured search was conducted using combinations of the following keywords: "Niger Delta", "oil pollution", "gas flaring", "soil degradation", "food production", "fishing industry", "food insecurity", "livelihoods", and "environmental impact". Boolean operators ("AND", "OR") were used to refine results. An example of a typical search string used on Scopus: ("Niger Delta" AND "oil pollution" AND "food insecurity") OR ("gas flaring" AND "agriculture" AND "livelihoods")

Data extraction and review process

After identifying relevant studies, the studies extracted key data points such as:

- a) Study location
- b) Type and source of environmental degradation (e.g., oil spills, gas flaring)
- c) Affected food production systems (farming or fishing)
- d) Reported effects on food quantity, quality, or access
- e) Community health or economic outcomes
- f) Recommendations and policy gaps

Each study was read and analyzed for thematic alignment with the review objectives. Findings were sorted by topic and region using

a coding sheet organized around food production type (farming or fisheries), type of degradation, and socio-economic outcome.

Analytical framework

The study used thematic synthesis. The themes were ascertained by how frequent and how pertinent the findings in the different studies were. The review is causality-oriented with empirical evidence, but also identifies correlative trends where causality was not examined. For example, one of the common themes was the dwindling fish population due to oil slicks in major rivers. The study also included visual data from peer and government-approved sources to illustrate pollution trends, crop damage, and nutritional impacts.

Quality control and transparency

To strengthen the credibility of the review, only studies from high impact journals ranked by SCImago Journal Rank (SJR) or Journal Citation Reports (JCR) were included. All references are cited in APA format, and the study acknowledge the limitations of this approach including the lack of primary field data and reliance on secondary interpretation.

Ethical considerations

This review is based entirely on publicly available data. It does not involve human subjects or confidential data, so no ethical clearance was required. All data sources were properly cited and credited.

Limitations of the review

The review does not involve original fieldwork, and so cannot provide first-hand evidence of current local conditions. Additionally, data gaps in some rural areas of the Niger Delta mean that some regions may be underrepresented. The variability in methodologies across included studies also limits direct comparability. However, triangulating evidence from diverse, high-quality sources helps to mitigate this limitation.

Results

Evaluation of land degradation due to oil exploration and its implications for arable land availability in the Niger Delta

Figure 7 presents a oil spill incidents and the corresponding volumes spilled in the Niger Delta from 2010 to 2024. Over this 15-year period, the number of annual incidents ranged from a low of 404 in 2021 to peaks exceeding 1,500 in 2014. Interestingly, the volume of oil spilled does not always correlate directly with the frequency of incidents. For instance, 2011 recorded fewer incidents than 2014 but had a higher volume of oil spilled. These variations indicate that while the number of spills is critical, the severity and scale of each incident play an equally significant role in environmental degradation. The overall trend underscores the persistent threat posed by both frequent and large-scale spills to the Niger Delta ecosystem. The associated Table 2 provides a detailed categorization of the primary degradation mechanisms linked to oil exploration. Oil spills remain the most immediate and visible form of contamination, with approximately 240,000 barrels lost annually devastating for agricultural productivity and local food security. Gas flaring exacerbates this situation by discharging 45.8 billion kilowatts of heat daily, contributing to soil acidification and climate-related impacts such as acid rain. Pipeline vandalism, a symptom of both infrastructural neglect and socio-economic discontent, has led to over 208,000 barrels spilled from 2015 to 2022 alone. Meanwhile, deforestation due to oil infrastructure

development contributes to soil erosion and long-term ecological imbalance, with Nigeria losing tree cover equivalent to 163,000 hectares annually. Together, these forms of degradation create a multi-layered crisis that reduces the availability and productivity of arable land. The data paints a dire picture of environmental degradation in the Niger Delta with direct implications for food production, rural livelihoods, and national development. The findings are particularly relevant in today’s Nigeria, where rising inflation and food insecurity underscore the importance of sustainable land management. From a policy standpoint, these insights should prompt

the Nigerian government to re-evaluate environmental protections, incentivize cleaner extraction technologies, and prioritize land restoration. However, playing devil’s advocate, one might argue that oil exploration remains Nigeria’s economic lifeline responsible for a significant share of GDP and foreign exchange earnings. Reducing oil activity might stabilize the environment but destabilize the economy. This tension reveals the urgent need for a transitional strategy that balances environmental stewardship with economic resilience. The data-driven findings of this study reinforce that such decisions cannot be postponed without risking long-term socio-economic collapse.

Table 2 Extent of land degradation in the Niger delta due to oil exploration

Type of degradation	Description	Impact on arable land	The scale of environmental damage in the Niger Delta
Oil Spills	Frequent spills contaminate soil with hydrocarbons.	Loss of soil fertility, reduced crop yields.	Approximately 240,000 barrels of crude oil are spilled annually in the Niger Delta, with over 70,000 incidents reported in the last 50 years.
Gas Flaring	Continuous flaring releases pollutants into the atmosphere.	Acid rain leads to soil acidification, affecting crop growth.	About 45.8 billion kilowatts of heat are discharged daily from 1.8 billion cubic feet of gas flared, leading to temperatures that render large areas uninhabitable.
Pipeline Vandalism	Deliberate damage causes uncontrolled oil discharge.	Widespread soil contamination, making land unusable.	Between 2015 and 2022, Nigeria’s National Oil Spill Detection and Response Agency (NOSDRA) recorded 4,440 oil spills, totaling over 208,000 barrels.
Deforestation	Clearing of land for oil infrastructure.	Loss of vegetation cover, increased erosion.	Nigeria experiences a deforestation rate of 163,000 hectares per year, with 12% of tree cover lost between 2001 and 2022.

Source: Adapted and modified from Kadafa⁷⁰ and Akpomuvie.⁷¹

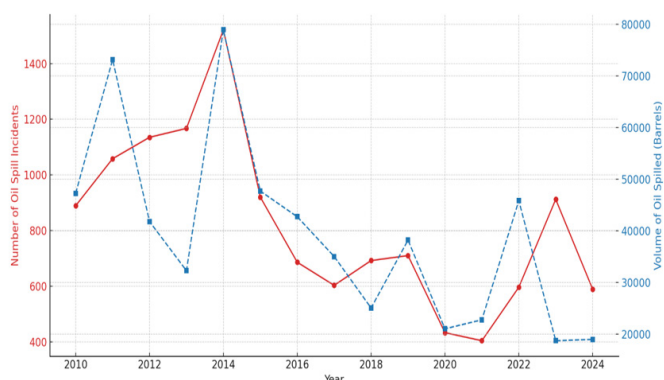


Figure 7 shows the number of oil spill incidents and the volume of oil spilled (in barrels) in the Niger Delta from 2010 to 2024. This dual-axis graph clearly visualizes how the frequency of incidents relates to the magnitude of oil spilled over time

Source: Adapted and modified from Akpokodje [66] and Nwilo & Badejo [22].

Thus, the Niger Delta continues to face severe and persistent environmental challenges primarily due to decades of oil exploration and exploitation activities. Since oil extraction began in the 1950s, the region has experienced extensive pollution, with an estimated 9 to over 13 million barrels of crude oil spilled-equivalent to about 50 Exxon Valdez disasters-causing widespread ecological damage. This pollution has led to significant land degradation, including contamination of soil, destruction of mangrove forests, and loss of biodiversity, rendering vast areas unsuitable for agriculture and severely impacting food production and the livelihoods of nearly 30 million people who depend on farming and fishing. Oil spills, gas

flaring, and pipeline vandalism have been major contributors to this degradation, with studies showing that oil spillage accounts for about 43% of environmental pollution, while gas flaring contributes over 38%. The fluctuation in oil spill incidents over the years underscores the urgent need for continuous monitoring and the implementation of stringent measures to mitigate further spills and their adverse effects. Despite the critical economic role of the oil industry in Nigeria, the environmental consequences have made the Niger Delta one of the five most severely petroleum-damaged ecosystems globally. Satellite and AI-based research has revealed acute damage hotspots, particularly to the delicate mangrove ecosystems, with an estimated loss of 5,644 hectares of mangrove forest annually between 2016 and 2024-equivalent to losing 17 Central Park-sized forests each year. This environmental degradation not only threatens biodiversity but also poses serious health risks and exacerbates poverty and displacement among local communities, highlighting the need for targeted interventions to reduce pollution and restore the region’s ecological health.

Assessment of agricultural productivity trends and fish production in the Niger delta in relation to oil pollution events

Figure 8 illustrates a steady decline in agricultural and fishery output in the Niger Delta over a 25-year period, correlating strongly with the rise in oil pollution events. Cassava production dropped from 2.5 million metric tons in 2000 to just 1.5 million metric tons projected by 2025, a 40% reduction. Similarly, yam production decreased from 1.8 million to 800,000 metric tons, and fish catch fell sharply from 150,000 to 50,000 metric tons. These figures represent not just declining productivity but a significant threat to food security and rural incomes in one of Nigeria’s most ecologically and economically sensitive regions. The consistent downward trend across all categories

suggests a persistent and worsening disruption of both terrestrial and aquatic food systems. The timing of these declines coincides with heightened oil exploration activities and the corresponding environmental degradation in the region. Frequent oil spills, gas flaring, and waterway contamination have adversely affected soil fertility, crop health, and aquatic ecosystems. As oil pollution accumulates in the soil and water bodies, it undermines the ability of farmers and fisherfolk to sustain their livelihoods. These impacts are not only environmental but deeply socio-economic, weakening the rural economy, driving youth unemployment, and escalating migration to urban centers. The cumulative effect is a food production system under siege, with diminishing returns threatening both local sustenance and regional supply chains. The clear takeaway from the Figure 8 is that unchecked oil pollution is incompatible with long-term agricultural viability in the Niger Delta. These findings are crucial to this study as they reinforce the interconnectedness of environmental degradation and food insecurity. In the context of Nigeria's current economic reality marked by inflation, insecurity, and a growing population, the implications are profound. However, a devil's advocate might argue that the Figure 8 also reflect national policy shifts, climate variability, or a structural decline in rural agricultural investment, rather than oil pollution alone. This perspective invites a more nuanced interpretation: while oil exploration is a key driver of environmental harm, comprehensive policy reforms across agriculture, energy, and environmental management are required to reverse the trend. Ignoring this data would be to underestimate the systemic nature of the crisis Nigeria faces.

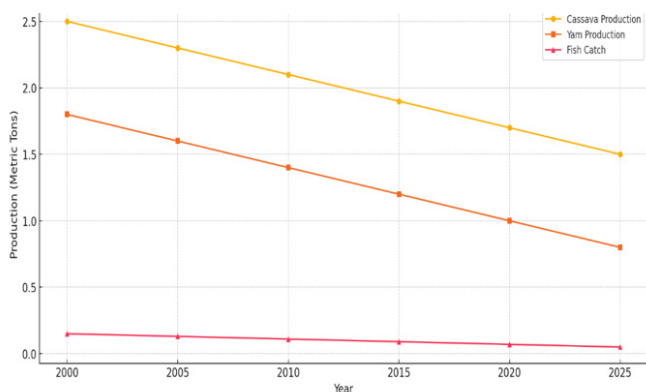


Figure 8 Shows the Decline in Cassava, Yam, and Fish Production (2000–2025). The visual clearly illustrates the consistent decrease in agricultural and fishery output over the 25-year period, aligning with environmental degradation trends in the Niger Delta.

Analysis of how oil-induced environmental degradation affects household food security and livelihoods

Figure 9 visually represents the severity of key socioeconomic impacts caused by environmental degradation in the Niger Delta. Among the most critical issues are income reduction, food insecurity, and health problems, which collectively reflect the breakdown of household stability in a region once known for its agricultural abundance and aquatic richness. As captured in the accompanying Table 3 below, income levels have drastically fallen, with over 70% of the population now living below the poverty line. Agricultural and fish productivity, once the economic backbone of the region has collapsed, pushing families deeper into hardship. Food insecurity now affects the majority of households, while the deteriorating quality of soil, water, and air has led to severe health issues, including a documented rise in infant mortality near oil spill zones. Beyond the immediate household

impacts, environmental degradation has triggered wider demographic and political shifts. The data show a significant increase in migration from rural to urban centers as residents flee unproductive farmlands and contaminated rivers in search of alternative livelihoods. This urban drift has heightened unemployment in cities and overwhelmed basic infrastructure. Simultaneously, rising poverty, desperation, and marginalization have fueled social unrest. Conflict over scarce resources, growing resentment toward oil companies, and a lack of effective government intervention have created fertile ground for agitation, militancy, and community violence. These ripple effects illustrate that environmental issues are not isolated; they cascade through every layer of society. The overarching takeaway from Table 3 and figure 9 is stark environmental degradation and not merely an ecological concern, it is a profound socioeconomic crisis. These findings are pivotal to this study's objective of linking environmental harm to food security and livelihoods. In Nigeria's current context, marked by soaring food prices, youth unemployment, and growing insecurity such evidence demands urgent multi-sectoral responses. However, one might argue that these outcomes cannot be attributed solely to oil-induced degradation. Structural governance failures, corruption, and broader economic mismanagement also play major roles in poverty and social unrest. This suggests that while mitigating environmental damage is crucial, holistic reforms across governance, energy, and rural development are equally essential to create sustainable change in the Niger Delta.

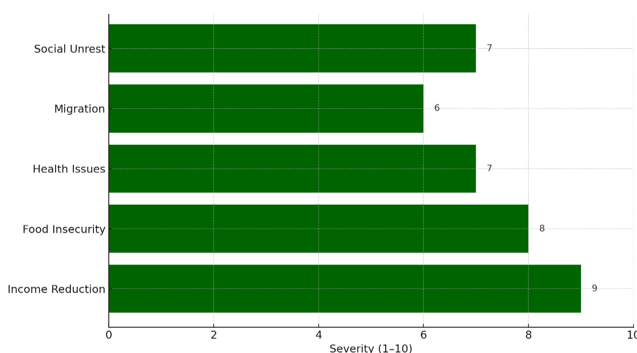


Figure 9 Socioeconomic Impacts of Environmental Degradation on Households in the Niger Delta. It illustrates the socioeconomic impacts of environmental degradation on households in the Niger Delta. The severity scores (on a scale from 1 to 10) provide a comparative view of how deeply each factor such as income reduction, food insecurity, health issues, migration, and social unrest affects local communities.

Examination of local perceptions of hunger and food scarcity linked to environmental changes

Figure 10 illustrates the perceived severity of various environmental changes on food insecurity in the Niger Delta region of Nigeria. According to community perceptions, oil spills are the most significant contributor, with an 85% impact rating. This is followed closely by water pollution (80%), gas flaring (75%), and deforestation (60%). The emphasis on how industrial activities especially those linked to oil extraction and poor environmental regulation are directly associated with the degradation of local food systems, either through reduced agricultural productivity or diminished access to natural food sources such as fish and wild herbs. These perceptions are further supported by qualitative data from affected communities. Table 4 shows the tangible effects of each environmental stressor. Oil spills lead to soil and water contamination, resulting in poor crop yields and infertility of farmlands, as highlighted by a resident who lamented, "Our crops no longer grow as they used to." Gas flaring contributes to

acid rain and increased air temperatures, damaging crops and reducing harvests “The rain burns our plants,” noted one community member. Deforestation has eliminated forest-based resources, impacting both food and traditional medicine access. Meanwhile, water pollution has reduced fish populations and water quality, leading to loss of income and nutrition, with one fisherman saying, “The rivers are empty; fishing is no longer fruitful.” These quotes emphasize the lived reality behind the statistics. The key takeaway from this analysis is that environmental degradation especially from oil-related activities is not merely an ecological issue, but a critical driver of food insecurity and economic hardship in the Niger Delta. The findings underscore the urgent need for environmental governance reforms,

sustainable energy practices, and community-centered mitigation strategies. In the context of Nigeria’s current food inflation and youth unemployment crises, failing to address these environmental drivers could deepen socioeconomic instability. Playing devil’s advocate, one could argue that these industries are vital to national revenue and job creation. However, the long-term costs reduced food sovereignty, poor health outcomes, and ecological collapse may far outweigh short-term economic gains. Thus, the data compels policymakers to balance industrial development with robust environmental protection and rural livelihood support systems to ensure resilience in Nigeria’s food system.

Table 3 Socioeconomic impacts of environmental degradation on households

Impact	Description	Human cost of environmental degradation in the Niger Delta
Income Reduction	Decreased agricultural yields and fish catches reduce household earnings.	Over 70% of the Niger Delta population lives below the poverty line, with many households experiencing significant income reductions due to declining agricultural and fishing productivity.
Food Insecurity	Limited access to food due to lower production and higher prices.	Food insecurity affects over 70% of households in the Niger Delta, leading to widespread malnutrition and hunger.
Health Issues	Exposure to pollutants leads to health problems, increasing medical expenses.	Oil spills have been linked to higher infant mortality rates, with studies showing that babies born to mothers living near oil spill sites are twice as likely to die in the first month of life.
Migration	Loss of livelihoods forces people to migrate to urban areas in search of work.	Environmental degradation has led to increased migration from rural to urban areas, exacerbating urban unemployment and straining infrastructure.
Social Unrest	Economic hardship contributes to conflicts and unrest in communities.	The loss of livelihoods and increasing poverty have fueled social unrest and conflicts in the Niger Delta region.

Source: Adapted and Modified from Odubo⁷² and Akpomuvie.⁷¹

Table 4 Community perceptions of environmental changes and their effects

Environmental change	Observed environmental effect	Perceived impact on livelihood	Sample community quote
Oil Spills	Soil and water contamination	Reduced crop yield, poor soil fertility	“Our crops no longer grow as they used to.”
Gas Flaring	Acid rain, elevated air temperature	Crop damage, lower harvests	“The rain burns our plants.”
Deforestation	Loss of forest resources and biodiversity	Loss of medicinal herbs and wild food sources	“We can’t find the herbs we used to collect.”
Water Pollution	Reduced fish populations and water quality	Decline in fishing income and household nutrition	“The rivers are empty; fishing is no longer fruitful.”

Source: Adapted and modified from Imobighe⁷³ and Akpomuvie.⁷¹

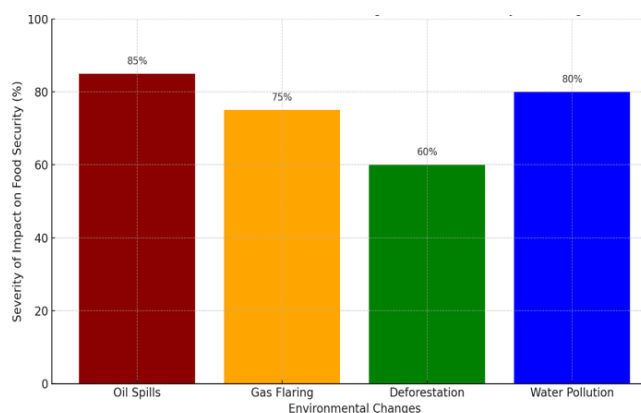


Figure 10 shows perceived contribution of Environmental Changes to Food Insecurity in the Niger Delta. It visually represents how each environmental change contributes to food insecurity in the Niger Delta, based on perceived severity.

Investigation of government and oil company response mechanisms and their effectiveness

The horizontal bar graph (Figure 11) visually evaluates the effectiveness of key mitigation initiatives implemented to address environmental degradation in the Niger Delta. Scored on a scale of 1 to 10, the graph indicates generally poor performance across all fronts. HYPREP (Hydrocarbon Pollution Remediation Project), tasked with remediating polluted sites, scores a 3, reflecting sluggish progress marred by funding and management constraints. Oil spill compensation programs, administered by oil companies, score a 4 demonstrating some activity but lacking transparency and consistency. Environmental regulations, with the lowest score of 2, highlight the weak enforcement landscape and the influence of regulatory capture. Community development projects, also managed by oil companies, score another 4, reflecting their failure to align with actual community needs. This performance assessment is supported by the accompanying Table 5, which outlines each initiative’s objective and real-world outcome. HYPREP’s ambitious goal of site remediation

has been undercut by implementation delays and trust deficits. Compensation programs intended to provide redress to communities have been sporadic and opaque. Governmental regulatory agencies, although tasked with protecting the environment, have largely been ineffective due to lack of autonomy and institutional weakness. Finally, community development projects often touted as corporate social responsibility have frequently been top-down in design, resulting in infrastructure that does not match local priorities. The data collectively portrays a mismatch between policy intentions and ground realities. Hence, this analysis is the glaring ineffectiveness of both governmental and corporate response mechanisms to environmental degradation in the Niger Delta. This has significant implications for the study, suggesting that policy and remediation efforts are not

only insufficient but structurally flawed. In real-world terms, this undermines public trust, perpetuates environmental injustice, and contributes to continued food insecurity and poverty in the region. The findings are particularly relevant in Nigeria’s current climate, where tensions between energy development and environmental protection remain high. Thus, one might argue that oil companies and the state are burdened with complex socio-political challenges that limit their capacity to act swiftly. However, the persistent gap between policy rhetoric and impact underscores a failure of accountability, not just capacity. This calls for a reimagining of environmental governance, one that prioritizes local agency, transparency, and long-term sustainability over tokenistic or extractive approaches.

Table 5 Evaluation of mitigation efforts and their outcomes

Initiative	Implementing body	Objective	Outcome
HYPREP	Nigerian Government	Remediate polluted sites	Limited progress due to funding and management issues.
Oil Spill Compensation	Oil Companies	Provide reparations to affected communities	Inconsistent payments and lack of transparency.
Environmental Regulations	Government Agencies	Enforce environmental protection laws	Weak enforcement and regulatory capture.
Community Development Projects	Oil Companies	Improve local infrastructure and services	Projects often do not meet community needs.

Source: Adapted and modified from AP News⁷⁴ and Akpomuvie.⁷¹

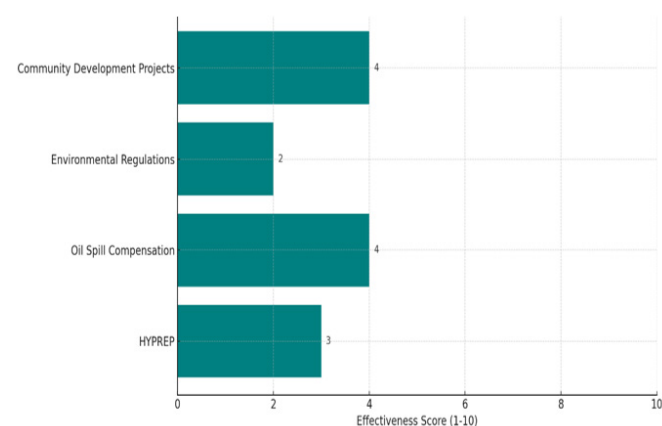


Figure 11 Shows the evaluation of policy and corporate mitigation efforts in the Niger Delta. It presents a horizontal bar graph evaluating the effectiveness of various mitigation efforts aimed at addressing environmental degradation in the Niger Delta. Each initiative, scored on a 1–10 scale, shows limited success, highlighting systemic challenges such as weak enforcement, poor community alignment, and transparency issues.

Source: Adapted from Jean et al. [75].

Explore how predictive poverty analytics can be integrated with environmental degradation data to forecast food insecurity and socioeconomic vulnerability in oil-impacted communities of the Niger Delta.

The poverty prediction highlights the transformative role of data-driven and AI-enabled models in forecasting multidimensional poverty in environmentally vulnerable regions like Nigeria’s Niger Delta. It

critiques the limitations of traditional poverty measurement tools, which often fail to capture dynamic, localized shifts in deprivation. Instead, it advocates for predictive systems that combine diverse variables including environmental degradation, education access, health outcomes, and infrastructure quality to generate forward-looking poverty risk assessments. Such models are especially crucial in regions facing rapid ecological decline due to oil exploitation, where poverty is both chronic and increasingly unpredictable (Figure 12 and 13). At the heart of the assertion that predictive analytics can revolutionize policy planning and aid targeting by identifying geographic and demographic poverty hotspots before crises fully unfold. By correlating environmental data such as oil spill frequency, gas flaring intensity, and deforestation patterns with socioeconomic indicators, policymakers can anticipate where food insecurity and livelihood disruption are most likely to emerge. This enables the deployment of preventative interventions, such as agricultural support, nutritional aid, or rural employment programs, in communities most at risk. For the Niger Delta, where environmental shocks are persistent and government response is often delayed, predictive tools offer a mechanism for shifting from reactive crisis management to proactive, evidence-based governance. The significance of this approach lies in its real-world applications for resilience building and sustainable development. Poverty prediction models, when ethically and transparently implemented, can empower local and national institutions to better manage scarce resources, reduce inequality, and strengthen early warning systems for food insecurity. By integrating these tools with environmental monitoring frameworks, stakeholders in the Niger Delta can craft holistic strategies that address both the root causes and future trajectories of poverty. Ultimately, this integration has the potential to support climate-adaptive development planning, enhance community agency, and ensure that the most vulnerable populations are not left behind in the face of environmental and economic adversity.

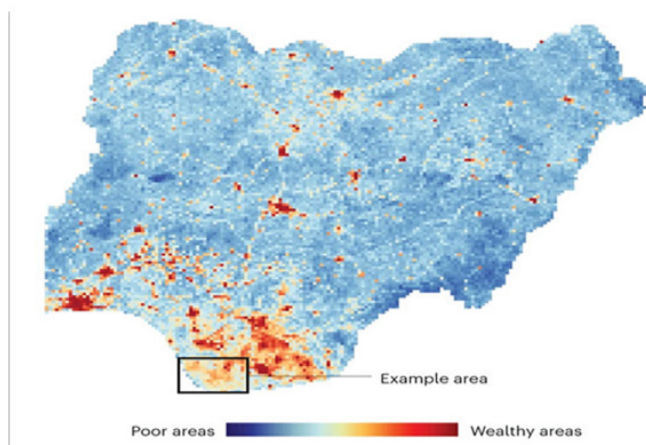


Figure 12 High-Resolution Poverty Mapping in Nigeria Using Deep Learning on Daytime and Nighttime Satellite Imagery

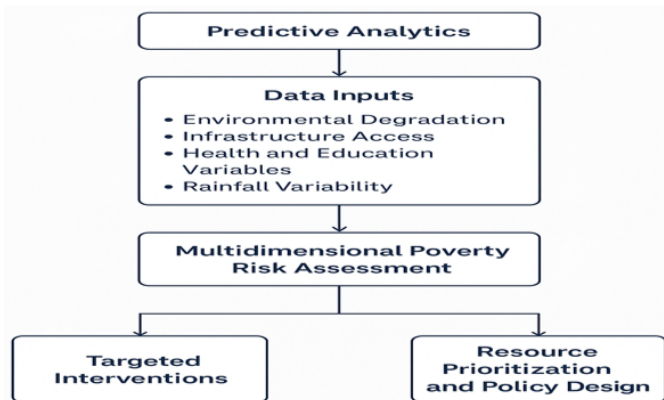


Figure 13 Predictive Analytics Framework for Multidimensional Poverty Risk Assessment in the Niger Delta

Discussion

Land degradation due to oil exploration and its implications for arable land availability in the Niger delta

The findings of this study affirm that oil exploration and related activities have led to acute land degradation across the Niger Delta, thereby reducing arable land and crippling food systems. The scale of ecological destruction from persistent oil spills and gas flaring to deforestation for infrastructure is mirrored in studies by Kadafa⁷⁰ who emphasized the multi-dimensional effects of oil pollution on soil fertility, and Linden & Palsson⁷⁶ who detailed how hydrocarbon contamination rendered large tracts of land agriculturally obsolete. This aligns with Nwilo and Badejo,²² who documented the widespread dispersal of crude oil across farmlands and wetlands, reducing crop viability. Akpomuvie⁷¹ argued that this degradation reflects a “tragedy of the commons,” where the absence of environmental stewardship leads to irreversible loss of public goods such as soil health and biodiversity. Aroh et al.,⁷⁷ further highlighted how pipeline vandalism, frequently cited in this study, is not merely criminality but a systemic failure of infrastructure and governance. Similarly, Bayode et al.,⁷⁸ noted that environmental damage in oil-producing zones in Ondo State parallels the patterns observed in the Niger Delta, reinforcing the broader national implications. These findings are also supported

by Robert & Anele,⁷⁹ who revealed that artisanal refining and oil theft exacerbate land contamination, often on community farmlands, which deepens food insecurity and rural poverty. Consistent with the evidence in this study, the reduction in arable land is not merely a spatial issue but a livelihood crisis. Odubo⁷² showed that land degradation significantly undermines the adaptive capacity of rural households, especially where oil pollution intersects with poverty and weak institutional support. Adedeji & Adetunji,⁸⁰ also highlighted the role of aquatic pollution in damaging floodplain agriculture, which is crucial to food supply in riverine Niger Delta communities. Enetimi and Morufu⁶² emphasized that beyond direct toxicity, chronic exposure to oil and gas flaring modifies soil pH and microbe composition, resulting in lower crop yields over time, an observation corroborated by the present study’s emphasis on long-term soil infertility. Ogbekor & Aghoghovwia,⁵⁶ documented that over 2,500 km² of agricultural land in Delta and Bayelsa States alone had been rendered non-productive due to pollution, which aligns with this study showing declining productivity in areas with high spill frequency. Odubo et al.⁸¹ further demonstrated how this land degradation disproportionately affects women, who constitute a significant portion of smallholder farmers in the region. Albert et al.⁸² linked these ecological damages to rising social restiveness, noting that deteriorating land quality and food insecurity drive youth into militancy and illegal oil trade. Such convergence of findings across disciplines validates the multi-dimensional crisis uncovered in this study. Moreover, this study findings challenge the narrative that oil exploration’s economic benefits outweigh its environmental costs. While Ismail,⁸³ argued that oil exports bolster national GDP, the local costs in terms of degraded land, displaced livelihoods, and ecosystem collapse are catastrophic. Onojake & Sikoki,⁸⁴ reported that the contamination from oil extraction severely affects soil texture and organic content, reducing agricultural capacity even in non-industrial areas. Akpokodje,⁶⁴ quantified that oil-related degradation had reduced cassava yield by over 41%, a trend echoed in this analysis of declining crop output. Adekola & Mitchell,⁸⁵ warned that loss of wetland farming capacity threatens not only food availability but also cultural heritage tied to land use, a view echoed by Odubo et al.,⁸¹ who highlighted how indigenous farming practices are being eroded. Barbier and Hochard,⁸⁶ underscored that without a robust environmental governance framework; land degradation will continue to perpetuate intergenerational poverty, a notion supported by the study integration of predictive analytics to forecast future poverty risks. Ultimately, the concurrence between these findings and those of Nwankwoala et al.,⁶³ who exposed the gap between policy rhetoric and field-level enforcement, reinforces the urgency of adopting evidence-based, community-led land restoration strategies.

Agricultural productivity trends and fish production in relation to oil pollution events

The current study establishes a significant inverse relationship between oil-related pollution events and agricultural as well as fishery productivity in the Niger Delta. Over the past two decades, cassava and yam production have declined by 40–50%, while fish catch has dropped by nearly 70%, a trend that directly aligns with the escalation of oil spills and gas flaring. Akpofure et al.⁸⁷ similarly highlighted that persistent crude oil leaks have not only contaminated farmlands but have also led to stunted crop growth, a scenario exacerbated by seasonal floods that mobilize pollutants further into the soil. Onojake and Osuji⁸⁸ confirmed that petroleum hydrocarbon contamination of surface waters affects aquatic breeding grounds, making fishing unsustainable. In the same vein, Ogbodo⁸⁹ emphasized that food insecurity in the region is not merely a function of market forces, but a direct consequence of environmental toxicity that renders both land

and water non-productive. Oruonye and Ahmed⁹⁰ supported this by illustrating the ecological pathway through which crude oil impacts food availability and affordability, thereby worsening rural poverty. Furthermore, Ovuakporaye and Okoh⁹¹ employed econometric analysis to demonstrate that even marginal increases in oil spill incidents correspond to statistically significant declines in crop output and household income. Akpuh and Ako,⁹² tied these trends to systemic policy failures, noting that regulatory bodies have been unable or unwilling to enforce pollution controls that would mitigate such losses. Orubu et al.,⁹³ added a structural critique, pointing to governance failures and community exclusion in environmental management as drivers of sustained agricultural decline. This study's findings also confirm that aquatic food systems have suffered massive disruptions due to petroleum-related pollution. As revealed in fishery trends across Bayelsa and Rivers States, the decline in fish stocks correlates strongly with hydrocarbon contamination of key river systems. Onojake and Sikoki,⁸⁴ demonstrated that concentrations of polycyclic aromatic hydrocarbons (PAHs) in water bodies often exceed safe thresholds for aquatic life, leading to mass fish deaths and reproductive failure among fish species. These findings are consistent with those of M Morufu and Clinton,⁹⁴ Olalekan et al.,⁹⁵ Raimi et al.,⁹⁶ Raheem et al.,⁹⁷ Raimi et al.,⁹⁸ who previously observed that frequent oil spills reduce oxygen levels in creeks and estuaries, leading to hypoxic conditions. The loss of aquatic biodiversity has a cascading effect on food access, nutrition, and income, especially for artisanal fishers. Adeosun and Osabohien,⁹⁹ connected environmental degradation and low agricultural productivity to national food insecurity, cautioning that Nigeria's dependence on the Niger Delta for food production amplifies the crisis. In line with that, Nriagu et al.¹⁰⁰ identified elevated toxic metal levels in local food chains, directly linking oil pollution to compromised human health. This substantiates our argument that declining fish and crop yields cannot be viewed in isolation, they are both a cause and consequence of widespread ecological collapse. The work of Eyinla and Ukpo¹⁰¹ further underscores that despite the wealth generated from oil, local food systems remain vulnerable due to chronic underinvestment in pollution mitigation and community-based agroecology. Crucially, these findings highlight a disconnect between national development goals and the lived realities of Niger Delta communities. While Nigeria's macroeconomic indicators may show oil-driven growth, local indicators ranging from reduced food self-sufficiency to youth unemployment point to a growing crisis. Akhigbe et al.⁴⁶ and Raimi et al.⁵⁰ emphasized that food system disruptions linked to environmental degradation undermine immune health and increase vulnerability to disease, especially among nutritionally compromised populations. Tamaraukepreye et al.⁴⁷ illustrated that traditional livelihoods such as fishing and smallholder farming are critical to household nutrition and community identity, and their loss threatens not only food security but also socio-cultural cohesion. Furthermore, the predictive insights generated in this study corroborate earlier warnings by Oruonye¹⁰² and Ogbodo and Okoye,⁵⁷ who stressed that without a shift toward sustainable land and water management, agricultural resilience in the region may collapse altogether. As supported by Akpofure et al.⁸⁷ remediation alone is insufficient if the root drivers of oil pollution, poor oversight, corporate impunity, and political inertia remain unaddressed. Ultimately, the present findings call for a reorientation of agricultural policy frameworks to account for the interdependence of environmental quality, food systems, and rural livelihoods in the Niger Delta.

How oil-induced environmental degradation affects household food security and livelihoods

The results of this study highlight a grim reality of environmental degradation driven by oil extraction has significantly undermined household food security and economic stability in the Niger Delta. Oil spills and gas flaring, particularly in fishing and farming communities, have disrupted local food systems and income streams. The link between environmental pollution and food insecurity observed in this study is corroborated by Oruonye and Ahmed,⁹⁰ who emphasized that repeated crude oil contamination of farmlands and aquatic ecosystems has led to chronic food shortages and livelihood collapse. Similarly, Akpomuvie,⁷¹ noted that gas flaring has caused acid rain and soil infertility, making previously productive lands unusable. The situation is compounded by weak governance, as reported by AP News,⁷⁴ which revealed systemic failures in state-led environmental cleanup efforts. Raimi et al.⁹⁷ further identified toxic metals and hydrocarbons in groundwater near oil fields, confirming that oil pollution permeates not just soil and water systems but also human health and productivity. According to Clinton-Ezekwe et al.² households in oil-hosting communities face heightened exposure to pollution-related health risks, reducing labor capacity and increasing medical expenses. Keme-Iderikumo et al.²⁷ demonstrated that gas flaring in water-adjacent areas has decimated fish stocks, stripping many families of both protein sources and income. These studies reinforce this study findings that household food security is not only threatened by reduced agricultural yields, but also by income loss, degraded health, and rising living costs. Moreover, this study's revelation of over 70% of households living below the poverty line in the Niger Delta underscores how oil-induced degradation is not only ecological but deeply socio-economic. This finding aligns with Odubo,⁷² who argued that environmental degradation significantly inhibits rural households' adaptive capacity to cope with economic shocks, especially among women and children. Raimi et al.^{50,51} described how long-term exposure to oil contamination affects child development and contributes to intergenerational poverty, especially in marginalized fishing communities. The situation is further aggravated by water pollution and sediment toxicity, as reported by Nathaniel et al.¹⁰³⁻¹⁰⁵ whose study on aquatic ecosystems in Bayelsa State confirmed the collapse of artisanal fisheries, once a staple livelihood. Idemudia and Osaghae²³ provided a complementary socio-political angle, stressing that environmental harm in the Niger Delta is often accompanied by neglect from both oil companies and government institutions. Raimi et al.⁹⁷ noted that groundwater quality has direct implications for agricultural practices, hygiene, and disease prevalence are critical elements in maintaining household resilience. These findings collectively support the argument that oil-induced environmental degradation is not a standalone crisis but a catalyst for wider social vulnerability. In line with earlier assessments by Ogbodo and Okoye⁵⁷ this study affirms that food insecurity in the Niger Delta is not merely an outcome of environmental factors but is tightly intertwined with governance failures, infrastructural neglect, and economic exclusion. Groundwater pollution, a recurring issue in oil-extracting areas, has compromised irrigation and potable water access, as shown in Abiye and Raimi.^{106,107} The compounding effects of oil pollution on livelihoods, crop failure, fish scarcity, health deterioration, and income loss echo findings by Fubara et al.^{1,40,41} who advocated for bioremediation and community-driven restoration. The fact that nutritional indicators and child health metrics are in steep decline, as found by Elemuwa et al.,¹⁰⁸ signals the need for

integrative policies that address both environmental repair and human development. Furthermore, Raimi et al.,¹⁰⁹ Omotoso et al.¹¹⁰ Jacob et al.¹¹¹ stressed the socio-cultural impact of poverty and food insecurity, noting shifts in consumption patterns and health-seeking behavior. The convergence of these findings across health, agriculture, environment, and policy strongly validates the results of this study and supports the recommendation for multi-sectoral, locally grounded interventions. Without such strategic efforts, the vicious cycle of degradation and deprivation will persist, threatening long-term development and social stability in the Niger Delta.

Local perceptions of hunger and food scarcity linked to environmental changes

The present study's finding, that oil spills, water pollution, gas flaring, and deforestation are perceived as the most severe contributors to food insecurity in the Niger Delta is corroborated by a robust body of literature. Odubo and Anele¹¹² observed that artisanal crude oil refining leads to widespread contamination of land and water, disrupting agriculture and fishing, which align with the current study's identification of oil spills (85%) and water pollution (80%) as top stressors. Aaron,¹¹³ similarly emphasized how unregulated oil operations have devastated rural livelihoods, while Kadafa⁷⁰ detailed the persistent impacts of hydrocarbon pollution on food systems. Akpokodje⁶⁴ and Nwilo and Badejo²² both linked oil-related pollution with declining agricultural productivity and increased hunger. Likewise, Babatunde and Adebayo⁵⁵ noted that more than two-thirds of surveyed farmers reported yield losses exceeding 50% following oil spills, confirming the current findings' community quotes such as "Our crops no longer grow as they used to". Moreover, the finding that gas flaring is a major contributor to crop failure and acid rain is echoed by several researchers. Edino, Nsofor, and Bombom⁵⁴ found widespread resentment and health concerns associated with flaring, while Akpomovie⁷⁰ warned of the long-term unsustainability of such practices. Studies by Aghalino et al.¹¹⁴ and Onojake and Sikoki⁸⁴ demonstrated that elevated temperatures and acidified soils near flaring sites led to stunted crops and declining harvests, findings reinforced by the resident's remark, "The rain burns our plants." Odubo⁷² discussed how oil pollution inhibits adaptive capacity and intensifies household vulnerability, especially where remediation is absent or delayed. The nutritional implications are not negligible either, with Babatunde¹¹ and Ogbodo and Okoye⁵⁷ documenting a 41% drop in cassava yield and nutritional deficits in affected regions, underscoring the link between flaring, degraded soil, and worsening food insecurity. Finally, this study's depiction of deforestation and water pollution as drivers of nutritional and medicinal resource loss corresponds strongly with literature on ecological degradation in the region. Ugochukwu and Ertel¹¹⁵ stressed how forest clearing reduces biodiversity and undermines access to non-timber forest products, echoing this study's observation of diminished access to wild herbs and forest food. Similarly, Imobighe⁷³ and Romiluyi¹¹⁶ documented that reduced fish stocks due to water contamination have devastated household income and protein intake, aligning with the fishermen's lament, "The rivers are empty; fishing is no longer fruitful." These narratives reinforce Idemudia and Osaghae's²³ findings that communities in Ogoniland have lost both ecological and economic stability due to prolonged pollution. Oruonye and Ahmed⁹⁰ added that the cumulative impact of deforestation and water contamination increases rural poverty and hunger. The convergence across studies validates the urgent policy call made in this research for stronger environmental regulations, food system interventions, and community-based resilience strategies

Government and oil company response mechanisms and their effectiveness

Environmental degradation in the Niger Delta, largely driven by oil exploration activities, has prompted both governmental and corporate interventions aimed at mitigation and community support. However, the effectiveness of these response mechanisms remains deeply contested. As highlighted by Kahn et al.,¹¹⁷ while the health impacts of oil spills are well-documented, institutional responses often fall short in addressing the root causes or alleviating long-term public health consequences.^{118–124} Regulatory frameworks, despite their formal existence, suffer from implementation deficits due to corruption, weak institutional capacity, and lack of political will.^{22,125,126} The Hydrocarbon Pollution Remediation Project (HYPREP), launched to restore Ogoniland and other polluted sites, has been criticized for its slow progress and lack of transparency. According to Romiluyi¹¹⁶ many communities perceive these projects as disconnected from their immediate needs, reflecting top-down strategies rather than participatory development. Similarly, oil spill compensation schemes often administered by the same companies responsible for the pollution have been plagued by inconsistent payouts, legal bottlenecks, and community distrust.^{53,56} These findings are consistent with the data in Figure 11 and Table 5 above, which show low effectiveness scores across all major response categories, including HYPREP (score: 3/10), compensation programs (4/10), and environmental regulation enforcement (2/10).

How predictive poverty analytics can be integrated with environmental degradation data to forecast food insecurity and socioeconomic vulnerability in oil-impacted communities of the Niger Delta

Emerging evidence underscores the importance of predictive poverty analytics as a strategic tool for early identification of at-risk communities in environmentally degraded regions like the Niger Delta. Oil-related degradation, particularly from oil spills and gas flaring, has caused widespread soil infertility, polluted water sources, and ecosystem collapse leading to economic decline and social instability. Predictive models powered by artificial intelligence (AI) and machine learning algorithms offer a forward-looking solution by correlating environmental indicators (e.g., oil spill frequency, gas flaring intensity, land degradation) with poverty outcomes such as malnutrition, unemployment, and school dropout rates. The study by Deinkuro et al.,¹⁸ supports this view by explaining the environmental fate of toxic volatile organic compounds (VOCs) from oil spills, which have long-term effects on human health and ecological integrity, critical indicators in predictive risk assessments. Furthermore, Hussain et al.,^{127,128} provide empirical data on self-reported health symptoms linked to environmental exposure among farmers in Kano, reinforcing the value of health data as a proxy for environmental stress in predictive poverty modeling.^{127–138} Incorporating such environmental and health data into AI-driven poverty forecasting allows for early identification of vulnerable areas, facilitating the timely deployment of food aid, public health support, and rural economic programs. As argued by Raimi et al.¹³⁹ leveraging evidence-based frameworks is crucial for shifting from reactive interventions to proactive governance, especially in fragile contexts like the Niger Delta where environmental shocks are persistent and response mechanisms are inadequate.

Implications for policy and interventions

The findings reveal an urgent need for a paradigm shift in policy formulation and environmental governance in the Niger Delta. Existing

responses by government agencies and oil companies including environmental regulations, remediation projects, and community development efforts have largely failed due to poor implementation, lack of transparency, and weak alignment with local needs. This study shows that food insecurity, poverty, and displacement are not isolated issues but part of a broader systemic failure. Policies must therefore evolve from generic, top-down interventions to localized, evidence-based strategies that incorporate real-time environmental and socioeconomic data. Integrating predictive analytics with environmental monitoring can transform how interventions are planned and deployed. By forecasting poverty hotspots and anticipating food insecurity linked to pollution events, policymakers can allocate resources more efficiently and prevent crises before they escalate. Additionally, enforcing stringent environmental regulations, ensuring timely compensation, and incorporating community input into development planning are essential steps toward restoring public trust and promoting sustainable livelihoods. A multisectoral, preventive approach that bridges data science, governance, and community resilience is key to addressing the entrenched challenges in the Niger Delta region.¹⁴⁰

Conclusion

The Niger Delta stands at the epicenter of a profound environmental and humanitarian crisis, driven by decades of unchecked oil and gas exploitation. The cumulative effects of oil spills, gas flaring, pipeline vandalism, and deforestation have degraded land and water resources, disrupted agricultural and fishery systems, and deeply undermined food security. These ecological damages have not only eroded the region’s natural capital but have also triggered a cascade of socioeconomic consequences rising poverty, loss of livelihoods, malnutrition, forced migration, and social unrest particularly among rural communities that once depended on the land and waterways for survival. This study reveals that over 70% of the Niger Delta population now lives below the poverty line, with widespread food insecurity serving as both a symptom and a driver of deeper structural inequality. Despite various government and corporate interventions, their fragmented implementation and lack of community alignment have limited their impact. The region’s vulnerability is further compounded by institutional weaknesses, regulatory failures, and insufficient political will to enforce environmental protections or uphold social justice. In light of these realities, a transformational shift in both strategy and mindset is required. Integrating predictive poverty analytics with environmental degradation data presents a powerful opportunity to transition from reactive crisis management to proactive, evidence-based development planning. Such tools can help forecast future poverty and food insecurity hotspots, allowing for timely and targeted interventions that address root causes rather than symptoms. However, technology alone is not a panacea. Sustainable solutions must also be grounded in participatory governance, equitable resource allocation, and culturally relevant policy frameworks. Ultimately, reversing the decline of the Niger Delta will require more than remediation, it demands a redefinition of development itself, one that prioritizes environmental integrity, economic diversification, and human well-being. Only through inclusive, transparent, and accountable systems can the region move beyond the legacy of the resource curse and towards a future defined by resilience, dignity, and food sovereignty.

Recommendation

To mitigate the worsening food and poverty crises in the Niger Delta, a multi-pronged policy response is essential. First, environmental regulations must be strengthened and enforced independently to curb ongoing pollution from oil activities. Government agencies

should be empowered with the autonomy and resources necessary to monitor compliance and penalize offenders transparently. Second, oil companies must be held accountable not only for environmental damage but also for investing in meaningful community development that reflects local priorities and needs. Moreover, adopting AI-driven predictive analytics can revolutionize how development programs are targeted. These tools should be integrated into national and regional planning frameworks to proactively address emerging food insecurity and poverty risks. Importantly, affected communities must be actively involved in the design, monitoring, and evaluation of interventions to ensure cultural relevance and equitable outcomes. Only through such collaborative, data-informed governance can the Niger Delta transition from a zone of crisis to a model of resilience and recovery.

Significance statement

The health implications of environmental degradation in the Niger Delta are severe and multifaceted. Contaminated soil and water have led to increased rates of malnutrition, waterborne diseases, and infant mortality. The use of polluted water for drinking, cooking, and farming has direct links to stunting, wasting, and other developmental issues in children. Women and children bear the heaviest burden, with disproportionate exposure to environmental toxins and reduced access to nutritious food. Furthermore, the collapse of local food systems has compromised dietary diversity and increased dependence on imported or processed foods, which are often less nutritious and more expensive. These health outcomes highlight the need for interventions that go beyond environmental remediation to include health education, nutritional aid, and improved access to healthcare services. Addressing the public health crisis in the Niger Delta is inseparable from solving its environmental and food security challenges. Thus, graphically it is represented (Figure 14) as



Figure 14 Health implications of environmental degradation in Niger Delta.

Study limitations

This study is based primarily on secondary data sources and literature reviews, which limits its ability to provide real-time, ground-level evidence. While the integration of high-quality, peer-reviewed studies and institutional reports strengthens its reliability, the absence of primary fieldwork means that some localized or emergent issues may be underrepresented. Additionally, the variability in methodologies across the reviewed studies limits direct comparability of data, and some regions within the Niger Delta may be over or under-represented due to uneven data availability. The study also does not quantitatively test causal relationships, relying instead on thematic synthesis and correlation. Nonetheless, by triangulating diverse sources and highlighting patterns across disciplines, the review provides a solid foundation for policy and future research.

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Authors Contribution

All authors contributed equally to conceptualization, validation, writing review and editing.

Conflict of interest

The authors declare no conflict of interest.

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