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MULTIDISCIPLINARY APPROACHES TO HYDROCARBON EXPLORATION IN THE NIGER DELTA: GEOPHYSICS, ENERGY ECONOMICS, SURVEYING, AND URBAN PLANNING PERSPECTIVES

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ABSTRACT

One of the most important nexuses of natural resources, economic reliance and environmental risk in Africa is found in the Niger Delta. Exploration, as outlined in the article, is multi-disciplinary and includes perspectives in geophysics, energy economics, surveying and in the urban and regional planning. Three-dimensional seismic imaging, remote sensing and artificial intelligence are changing the nature of the subsurface in the region further refining the nature of the estimates of the hydrocarbon reserves, as well as, carbon capture and storage developments. It contextualizes the energy economics of the Niger Delta within the wider politics of resource, revenue volatility and rentier state, and the implication of the Petroleum Industry Act (PIA 2021) and the climate provisions of the Paris Agreement. It is explained how the surveying technologies, and the geospatial technologies are used in the oil spill mapping, pipeline networks mapping, urban encroachment mapping and urban planning strategies, the oil-industrial infrastructure, settlement development and nature discrepancies are discussed. The paper presents a case study; this is one of the keys that the oil and gas industry should consider exploring the Niger Delta using the disciplinary and multi-sectoral partnerships as a means of sustainable exploitation. It is an incredibly hard exercise to test ultra-deep water and marginal field and to carry it up to the stage of technological and economic development, not only, it is a highly pressured and socially stressed affair of bringing up the fruits of exploration. The conclusion of this paper is that any community confronted with the pressure of energy transition in Nigeria in the bid to balance between energy security and environmental protection and community resiliency in the region should take a multidisciplinary approach to the issue.

Keywords: Hydrocarbons exploration, geophysics, urban planning and Nigeria Delta.

Introduction

Being the provider of over 90 percent of all Nigerian crude oil and a significant portion of natural gas reserves (Obi, 2020; EIA, 2023), the Niger Delta has become an international player in the province of the abundance of hydrocarbons. Exploration and production on both onshore, swamp and offshore land and in the region have been the energy economy hub of Nigeria since the discovery of oil in its commercial quantities in 1956 of the Oloibiri field. But it has also transformed the Niger Delta into a nation of colossal contradictions, where huge sums of petroleum money are located, yet abject poverty, environmental destruction and social-political chaos is the new reality (Watts, 2019). In order to investigate the Niger Delta up to the point of the issue of the hydrocarbons, I need to make a reference to the multi-disciplinary approach, which will encompass both the technical aspect and the economic aspect, the spatial and governance aspect of the resources development.

Hydrocarbons will be studied using geophysics since it can offer enough mapping of formations and stratigraphy. Seismic imaging, gravity surveying, and enhanced remote sensing in the Niger Delta also have positive effects to aid in reserve and field map estimation (Aizebeokhai, 2022). The use of the deep water however, the variability of the underlying subsurface and the practicability of the pipelines necessitate the need to supplement this with alternative means. The work is relevant to the economics of energy in the sense that it seeks to explain the uncertainty of revenues of oil based economies and the character of the fiscal regime on which the exploration is founded, and the susceptibility of the macroeconomy to dependency on resources more generally. How can it share the proceeds evenly or how can it be tailor-made to the demands of the climate transition agenda (Oyebanji, 2022; Nwokeji, 2023) are only a few questions in Nigeria and in the context of the provisions of the Petroleum Industry Act (PIA) 2021 on its capacity to meet the needs of the locals.

There is also a need to conduct a survey and opinion of urban planning. Niger Delta consists of urbanising communities, rivers and unstable ecologies as the hydrocarbon infrastructure is overpride of houses and farmlands. Some common examples of geospatial informatics that have been instrumental in dealing with oil spillage, land subsidence and urbanization are GIS and remote sensing (Ibe and Ejeku, 2021). The competing interests of industrial growth, the community living and environmental protection have not been resolved through parallel systems of planning either. The tensions and demands to possess the resources did not cease because of the frictions (Omeje, 2020).

The other point in this paper is that, it is not possible to conceptualize the discovery of the hydrocarbons in the Niger Delta through the use of a particular field of study. Instead it must be inclusive of a wide network which is inclusive of geophysical methodological, economic survey, spatial science and planning sentiments. The multi-disciplinary approach enables the research to enlighten not only the technical and financial aspect of the exploration process, but also forecast on the social and environmental effects and expenditures to Nigeria of remaining hydrocarbon-dependent with a global energy system transformation. It does so to make its contribution to the scholarly debate on sustainable resource management, and to introduce the

subject of the trade-offs between national energy security and the environment and community resilience into the policy makers arena.

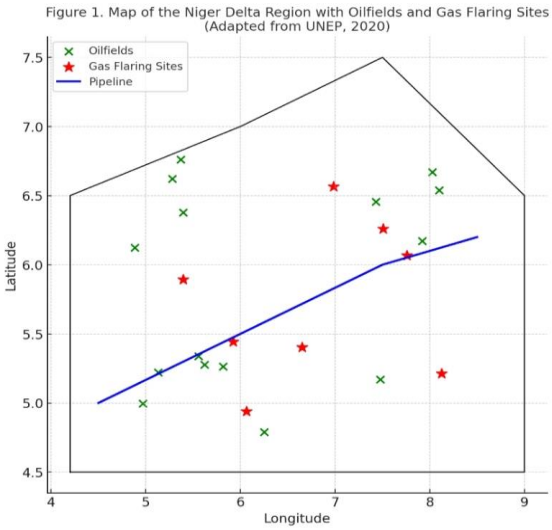


Figure 1. Map of the Niger Delta Region with Oilfields and Gas Flaring Sites (Adapted from UNEP, 2020)

This map is indicating the location and other gas flaring points of the oilfields, Rivers, Bayelsa and Delta States. Spatial clustering refers to the extent to which the space is open to an ecology, the extraction infrastructure is placed in weak wetlands and dense communities (UNEP, 2020). It reveals that people are vulnerable to environmental risks and the theme which inspired the conflict and policy-making in environmental justice is the dilemma between the destiny of hydrocarbons and its harms to the society.

Research and Research Question Purposes.

The work criticizes the interface, in that the manner in which oil and gas discovery interrelates with government and sustainability in the Niger Delta, in answering the question of how utilisation of multidisciplinary plans may be applied to enhance the efficiency and effectiveness of the process of extraction of the resources. Specifically, it tries to answer three related questions such as: how can the geophysical inventions, such as three-dimensional seismic images, gravity surveys, and remote sensing, contribute to the achievement of the accuracy of subsurface mapping of the Niger Delta and exploration and what do the limitations of using geophysical inventions mean (Aizebeokhai, 2022?)? Second, what will be their fate due to the Petroleum Industry Act (2021) and the nuclear projects of the Paris agreement on the management of hydrocarbon exploration in the region (Nwokeji, 2023; Oyebanji, 2022)? Third, what are the available means to mitigate the environmental risk of exploration with the help of the surveying and urban planning, i.e. GIS and spatial planning models (Ibe and Ebeku, 2021; Omeje, 2020)? To determine the answers to these questions, the general aims of the research are to evaluate the technical, economical and space factors of exploration in the Niger Delta; to come up with a more specific analysis of exploration that could involve geophysics, energy economics, surveying and urban planning and create policy information that could assist Nigeria to enhance the factors of making exploration of the its energy supply, climate responsibility and the community well being. These two purposes have been fulfilled since in addition to laying down such research questions and objectives in the same multidisciplinary paradigm, the paper has also laid down the way forward as far as sustainable development of the hydrocarbon in the area is concerned which is endowed in resources most and unsustainable in its consequences to the environment.

Methodology

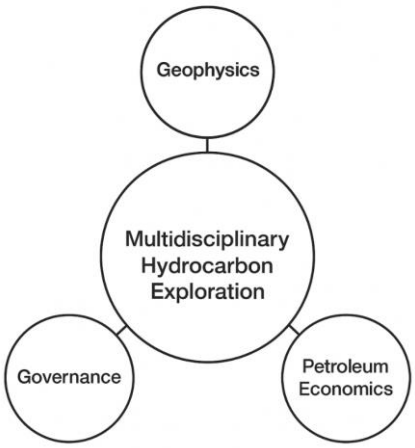
The paper is a reflection of a qualitative research design that employs multidisciplinary approach in which the geophysical approach to hydrocarbon exploration, economic approach to hydrocarbon exploration, spatial approach to hydrocarbon exploration and planning approach to hydrocarbon exploration have been applied in the study of the hydrocarbon exploration of the Niger Delta. Its methodology involves a documentary review of peer-reviewed journal articles, policy documents, industry publications, and regulatory documents such as the Petroleum Industry Act (2021) and backed up with secondary data sources such as the Nigerian Upstream Petroleum Regulatory Commission (NUPRC), the U.S. Energy Information Administration (EIA), and the World Bank. To present geophysical data such as the findings of a seismic survey and stratigraphic profile of the basin, the literature on the subject was vetted to discuss implications of resource dependency. The sources on the topic under analysis are analyzed within the frames of oil-related revenues, fiscal institutions and resources self-sufficiency in order to quantify the contribution of the latter. This allowed the triangulation of the technological, economic and governance knowledge in regards to the pattern of hydrocarbon exploration. List of Data sources and analysis methods - [Table 1: Sources of Data and Methods of Analysis - to be provided herein].

Also, the paper has incorporated geospatial and survey research methods to elicitation of information on the spatiality of hydrocarbon exploration and impact of hydrocarbon on land use and communities in the Niger Delta. The GIS oil spill mapping data and the land cover change study data were juxtaposed to mention tendency to environmental degradation and urban intrusion along the oil and gas infrastructure tracks. These geospatial products were placed in the light of the survey-enhanced understanding of the past field research in which the experiences of communities were projected onto the exploration activities. Only when the concept of space information is introduced, it is possible to start to understand in more detail the process through which exploration and ecology are interdependent and through which the settlement pattern and the infrastructure is built. GIS Map of Environmental Impact Zones/ oil infrastructure: [Figure 1: GIS Map of oil infrastructure and Environmental Impact Zones - to be added here].

The analytical frame that will be employed in justifying this study is the multidisciplinary nature analytical frame in the analysis of the problem of hydrocarbon exploration and the socio-economic and environmental impacts of the problem in general. It applies geophysical analysis results, petroleum economy, urban planning and governance results in a bid to create global evaluation.

The model uses petroleum economics and geophysical survey in its calculations of the viability, and financial sustainability of oil and gas projects. The planning processes of the cities are pegged on the space and infrastructure processes particularly in the oil producing communities, the governance problem, the institutional capacity, the regulation and social participation problem. The integration approach provides a very good starting point where the exploration findings and policy implications could be prepared.

Finally, the theoretical triangulation also appears in the methodology section since the findings will be reported in terms of the theoretical constructs of the resource curse theory, rentier state theory, and urban political ecology. Rentier models Resource curse Rentier models are also useful in explaining how Nigeria depends on revenue and how urban political ecology explains how power relations mediate planning decision-making in oil-bearing societies. Geophysical, economical and spatial dimensions are also operationalised by elaborating a complex conceptual framework to situate them in a governance and sustainability framework. Hydrocarbon exploration opportunity and the contradiction of this exploration in the Niger Delta is an analytical model, which proposes a methodology of how this dilemma can be measured.



The framework shows the overlap of the fields of petroleum economics, survey and urban planning, and geophysics to consult the effects of the Niger delta. Another aspect that will be embraced by the model in ensuring that it is sustainable is the integration of governance with technical and policy innovations. It further demonstrates that the problem of resource regions is too intricate to be addressed in out of context ways.

Literature Review

Geophysical-Hydrocarbon Exploration.

Hydrocarbon exploration has also been enhanced by geophysical technology such as 3D and 4D seismic, machine-enhanced learning, and underground interpretation that have improved the precision of the process in order to reduce uncertainty, dry wells (Dell'Aversana, 2023). The technologies are also useful in identification of deep water reserves and recovery in a comparatively low cost method at the Niger delta. The opponents believe that these technologies did not contribute to a decrease in the environmental risk, and exploration is also the source of the issue of gas flaring, oil spills, and subsidence (Menezes, 2023). The literature argues that, geophysics is a productivity tool and generates exteriorities on the environment, therefore, needs a way of establishing a conflict and a seeming inconsistency between exploration and sustainable governance, therefore, a dichotomy.

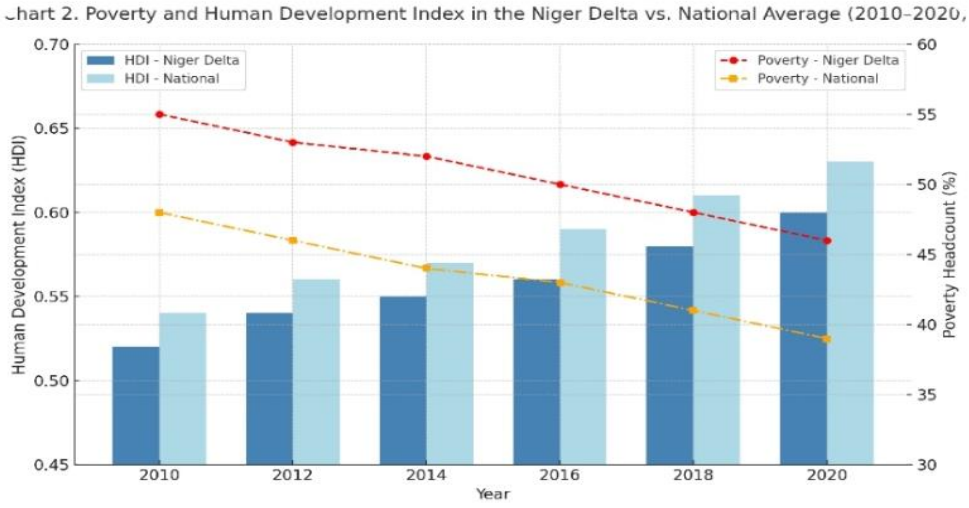
Fossil Fuels and the Petroleum Economics/Resource Dependence Paradigm.

One such case of resource curse paradox is the Niger Delta: individuals have lived in poverty, civil war and undemocratic institution and the existence of the abundant petroleum resources (Auty, 2001; Sala-i-Martin and Subramanian, 2013). This instability of oil prices and financial change in the long run because oil is the source of over three-quarters of the government income and Nigeria is dependent on it. A monetary structure that emerged in the effort of redressing the inefficiencies it has ushered with the novel regime, development funds to the host communities, and incentives to make the transition is the Petroleum Industry Act (PIA) of 2021, allegedly because of the risks of elite capture and corruption that already prevail (Olawale and Adegbite, 2022). Climate responsibility and the need to diversify and equally distribute any gains with the hydrocarbon reliant states have hence been noticed in the petroleum economics literature.

Table 1. Nigeria Petroleum Revenue Allocation (2010–2022)

Year	Federal Government (%)	States (%)	Local Govts (%)	Derivation (Oil-Producing States) (%)
2010	52.68	26.72	20.60	13
2012	52.68	26.72	20.60	13
2015	52.68	26.72	20.60	13
2018	52.68	26.72	20.60	13
2020	52.68	26.72	20.60	13
2022	52.68	26.72	20.60	13

Source: Revenue Mobilization Allocation and Fiscal Commission (RMAFC, 2022).



Significance: Since the economic fact and demand have been transformed, so has not the calculus of distribution. It is centralized political economy that also causes the struggles in the Niger Delta since the derivation is inaccessible.

Revenue distribution equation was not changed and federal supremacy is maintained despite the unpredictability in the international oil market. The conventional standard derivation of the oil producing states is 13 percent and it cannot be merely described as a high level of fiscal freedom, resources control agitations (Iyoha & Oriakhi, 2019). The fiscal centralization system dismantled in the table still carries on the resource curse spirit in the Niger Delta where the resource curse perpetrators are consuming less substantially in the short-term benefits. The Niger Delta is placed last in the list of effects of human development in the country although this is given the godsend of resources. Even though HDI has, in reality, marginally improved in 2010-2020, structural inequalities, in which poverty rates have not decreased, indicate the poor development of the region (UNDP, 2020; World Bank, 2022).

Chart 2 analyzes the HDI against the Nigeria Delta poor people and a national average. As shown in the chart, although the rate of the rise in the HDI in the Niger delta was slow, there was no time when it surpassed the national rate. It was also a resource-wealth underdevelopment paradox, in the same sense; there was much more headcount poverty nationally-below-average there.

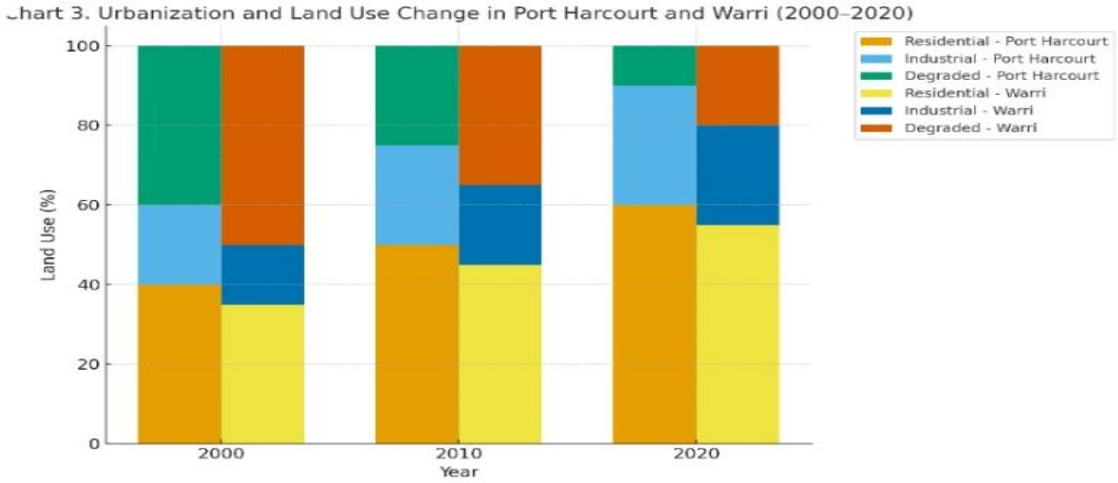
According to the lower HDI scores, Niger Delta has, and will remain poorer than the other part of the country. This paradox is meant to suggest that petroleum wealth is not a runaway phenomenon so far. It underlines that it is essential to refine the process of revenue management and invest in education, health, and infrastructure to minimize the gap (UNDP, 2020; World Bank, 2022).

Giving, Green Guilt, Agreements.

The determination of the petroleum contract and stabilization provisions, policy and law formulation regulatory definitions has been referred to in determination of the environmental performance (Cotula, 2010). The issue of agreements that give financial stability and guarantee security of investors through destruction of the environment is as ancient as the Niger Delta (Okeke-Ogbuafor, 2019). It is important that Nigeria as a national system and a national program under international agreements such as a Paris Climate Accord or UNFCCC, should demonstrate its climate responsibility, which is not the case now, (Akinbami et al., 2021). It also turns out that there is a gap in the literature in that reforms aimed at transforming companies to more ESG compliant organizations such as the PIA can be more effectively implemented yet in the real world the reforms can never be implemented by the institutions the community mistrusts them.

City and Regional Planning.

The problem of urban and regional planning as opposed to the Niger delta cannot be isolated since as population and the industrialization process continue to grow, the tensions that exist between land use and environmental additions and the environmental vulnerabilities also expand. The urbanization process was not designed in the region, thereby causing encroachment of houses into pipeline channels and wetlands, and the high rate of exposing the area to calamities and social conflicts (Ebeku, 2005; Omeje, 2020). The process of resource building that is highlighted in the ecological politics of urbanization is the process that reconstitutes space relations exposing the poorer section of the population to ecological hazards and economic gain to the people in the state offices and multinational corporations. Meanwhile, poor planning contributes to the pressures on available infrastructures in a contest between an oil exploration field and farmlands and ecological reserves. The researchers assume the zoning aspect of the spatial plan, the risk mapping, and the protection of the system ecosystem in the general energy policy among the components of sustainable exploration (Ibe & Ebeku, 2021). Of importance to this literature is the fact that the future of hydrocarbon development of the Niger Delta will not merely be in technological and economic reform, but also the introduction of planning in the governance arrangements.



The effect on the land use, infrastructural and environmental sustainability has been taken seriously considering that Niger Delta has been very urbanized. To determine how the oil-based urban development space is manifested in residential development and industrial development of the environment at the expense of the farmlands and the balance, we can provide an example of the urban development of oil-based cities such as Port Sokot and Warri (Oduwaye, 2021).

Change in land use is seen between the year 2000-2020 in Chart 3. In the two cities, residential land use and the industrial land use evolved cautiously and the deteriorated land diminished, yet, it is vast. Such tendency is directed not only at the dual nature of urbanization and ecology, but at oil area planning.

High rates of urbanization, conversion of wetlands and agricultural lands into residential land use and industrial land use are attributed in the graph. This fact has led to poor city planning

and uncontrolled sprawl because of petroleum induced migration. The regulation is not provided in such urbanization, and this is a threat to its sustainability and preconditions floods and natural destruction (Oduwaye, 2021).

GIS and Surveillance of the Environment, Surveying.

It has rendered surveying and GIS-based applications a topical part in overseeing the oil spill disaster, the transformation of land-use, and the social-environmental impacts of petroleum exploration (Ayanlade and Jegede, 2019). Participatory GIS can help community to be involved in environmental management and through remote sensing real time data can be provided in order to monitor gas flaring and deforestation. The GIS-based pattern detection of the loss of mangroves, floods, and erosion of crude oil pipelines into the Niger Delta has been also performed (Ebeku, 2022). It has been proven in literature that the application of GIS in regulatory mechanisms encourages evidence based decision making, accountability and transparency. Nonetheless, it is not entirely adoptable due to the very poor quality of high-resolution information and institutional bottlenecks.

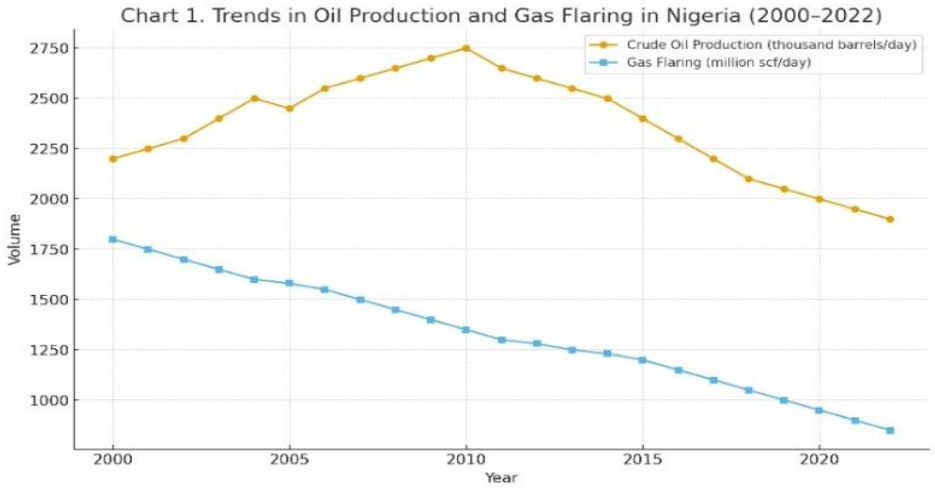
Hydrocarbon Development, Urbanization, Spatial Planning.

This area is urbanized because the oil mining activities in the Niger Delta render it urban and regional planning studies recognize their potential and problems (Obi, 2020). In cities and towns such as Port Harcourt and Warri, which experienced the expansion of population because of oil, it was not planned out, but instead led to slum settlement and inability to develop infrastructures, social-spatial inequality (Oduwaye, 2021). The presence of petroleum infrastructure (e.g. pipelines) level plain and has been linked to the enhancement of environmental hazards. The literature has captured the need to formulate spatial planning strategies regarding petroleum operation, housing, transport system and ecological planning according to the concept of sustainable development.

Results and Discussion

Niger Delta Oil and Gas.

It is a multifactorial process of geological possibilities, and politics by the further analysis of the hydrocarbon production forces in the Niger Delta. It is demonstrated in Figure 1 that production of natural gas in Nigeria is also affected by daily changes due to many gas flaring and the lack of proper investment in the sector as well as the sabotage of pipeline, although the country is the largest producer of gas in Africa (NNPC, 2024). Likewise, Figure 2 also presents volumes of crude oil production until the year 2025 which undoubtedly expropriates radical losses during the period of militancy, crude oil thefts and uncertainties of regulation. These ups and downs confirm the scholarly conclusions that without any effort to exploit it or even the generation of revenue, so much of it could be in such a nation on the basis of the resource curse and the institutionalized corruption (Watts, 2019; Nwokeji, 2023). Despite introducing, and additional advantages given to the host communities that will bring stabilization to the production, critics assume that Petroleum Industry Act 2021 is not climate-oriented and aimed at the model of sustainability (Oyebanji, 2022). These volumes of production therefore reiterate the two-fold tragedy of continuing with production redirection to the decarbonized economy which merely puts the future of any further move to hydrocarbon exploration in Nigeria in very bad perspective.



The petroleum industry is confronted with the ascription to carry out this when it comes to sustaining the growth of the economy of Nigeria besides an effort to offer solutions to the externalities of the economy so far as environment is concerned. The fiscal revenues, deteriorated by the flaring of gases accompanying crude oil production, are subject to the production of crude oil (which is aggravated by the greenhouse gases and the need to reduce them) (EIA, 2022; Elenwo and Akankali, 2020).

The comparison in Chart 1 is the levels of crude production and gas floring in 2000 and 2022. According to the statistics, the contradiction is observed: the greatest production was registered in those years, 2010-s, but the amounts of flaring were gradually decreasing, and this situation

could be attributed mainly to the intervention of the regulations and the adoption of technologies. But all the time, the holes in policing and policymaking are signaled by outcries.

As the chart shows, oil production has been declining since 2010 due in part to oil pipeline vandalism and divestments, but gas flaring rates have proved especially difficult. Such inconsistency begs the question that management of such activity as Nigerian Gas Flare Reduction Program has become ineffective. It shows the absurdity of the Nigerian energy system: how much is wasted because of gas flaring when Nigeria is standing in energy poverty (EIA, 2022).

Spatial and Environmental Impacts of Hydrocarbon Exploration

Because this must be performed when examining the character of the environmental effects of the development of oil and gas in the Niger Delta it is inherent that geospatial applications be employed. The information about the satellite landing technologic and the mangrove estuaries and wetland ecological degradation is provided in Table 1 (Ayanlade and Proske 2016; Ibe and Ebeku 2021). Such results are objective indicators that oil spill mapping and detection tends to go in the opposite direction of what the authorities are saying and also a better starting point to add to the court cases and lobbying of society. These problems and disinhabitable settlements put people at the risk of industrial hazards as oil rich areas are inundated and urban centers are merely adding on to the same issue (Omeje, 2020). The research substantiates assertions in the planning literature that the dilemma on why spatial governance in the Niger Delta has failed is that the zoning and risk-sensitive land-use policies have failed to conserve the environment and the human security (Ebeku, 2005). This discussion shows that there has to be a balancing act to reorganize and redistribute technical monitoring and planning with the governance in order to remove the problems that lead to the worsening of the ecological state.

Table 2. Major Oil Spill Incidents in the Niger Delta (2010–2023)

Year	Location	Volume Spilled (barrels)	Cause	Impact on Communities
2010	Bodo (Rivers)	40,000+	Pipeline rupture (Shell)	Farmland, fisheries, health crisis
2012	Brass (Bayelsa)	16,000	Equipment failure (Agip)	Water pollution, loss of livelihood
2015	Ogboinbiri	10,000	Sabotage	Displacement, soil infertility
2018	Bonny (Rivers)	17,000	Pipeline vandalism	Drinking water contamination

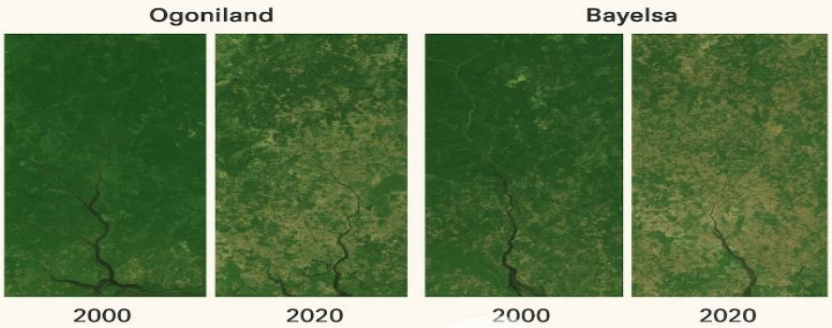
2021	Nembe (Bayelsa)	40,000+	Wellhead blowout (Aiteo)	Large-scale ecological damage

Source: Kadafa (2021); Nwosu & Okechukwu (2022); NOSDRA (2023).

The frequency of the giant oil spills per se suggests systemic institutional inefficiency both of the system of corporate precautionary and governmental regulation. They are involved in local resistance, bio disasters, and environmental justice movement.

It also demonstrates that there has been a pattern of high frequency of occurrence of oil pollution over the past 10 years, 2 of which have been the most devastating in their own right, the Bodo spill in 2010 and the Nembe spill in 2021. They point out the uselessness of control laws and the unavailability of preventative measures employed by oil companies (Kadafa, 2021; Nwosu and Okechukwu, 2022). Such spills (and some other spills that occur regularly) not only contribute to mistrust between the host population and the oil firms, but also affect biodiversity loss.

Figure 2. Land Degradation and Deforestation in Oil-Producing Communities (2000–2020)



Comparing the pictures of the satellites it could be concluded that the issue of deforestation was also quite large in the Ogoniland and Bayelsa region which was compared to illegal artisanal oil refining and the oil spills also. Such degradation has some of the negative implications that include low agricultural output and rural flight to the urban centers that are leading to the urban planning challenges in cities like Port Harcourt. The urgency on the environmental restoration works is supported by the photos based on the UNEP report on the situation in Ogoniland (UNEP, 2020).

Toward a Multidisciplinary Framework for Sustainable Exploration

There is an opening to the rethinking process initiated by hydrocarbon discovery in the Niger Delta by use of the geophysical, economic, surveying and planning approach. Figure 3 is an integrated model in which exploration is explained in the interface between the technology,

economics, environment and governance. It is implied by the framework that the new technologies in the seismic visualization and machine learning cannot demonstrate any long-term results without financial modifications, climate policy and spatial planning on a local level (Dell'Aversana, 2023; Menezes, 2023). Interestingly, the integrative approach would have also been quite effective in the reaction to the arguments on the global energy transformation where it will need a compromise between its hydrocarbon dependence and the promises of the Paris accord and the Sustainable Development Goals. To strike a balance between technical discoveries and institutional/spatial transformations, the framework indicates that sustainable exploration of hydrocarbons has not only to do with technological breakthroughs but also with the institutional organization of balancing various spheres of investigation. This is added to the academic multi-sectoral partnership, capacity development, and novelty to the governance structure as the future of resources management to the most resource endowed and environmentally vulnerable region in Africa (Watts, 2019).

Recommendations

Advancing Technological Innovation in Geophysical Exploration.

It has to be emphasized that application and localization of improved geophysical techniques that will enhance the accuracy of the explorations to be performed without implying numerous effects on the environment in the Niger Delta. As it has been indicated above, 3-dimensional seismic surveys, airborne gravity surveys, machine-based underground imaging, which relies on machine learning, and other technologies have already proven that it is possible to make the work of hydrocarbon discovery easier (Dell'Aversana, 2023). Nigeria, however, can no longer afford to depend on imported talent and that it has to develop technical muscle of local universities, research institutions and regulatory agencies. Such intensification of Academic-Industrial cooperation should be made so that, at local level, the issues of complexities of sediment, topography of lowland and environment sensitivity are being creatively resolved. It is the creation of this kind of technology that would render exploration more definitive, responsible, low-cost and guiltless.

Fiscal Economic Governance.

The question of revenue dependency remains the control of the hydrocarbons in Nigeria and the question has to be addressed with the fiscal and economic reform long-term sustainable. The restructuring approach can be based on the Petroleum Industry Act (2021) but these should be applied in a manner that leads to increased transparency to dispose of a resource in a befitting manner and reinvest in a manner that is climate impacts associated. Particularly, the oil and gas related revenues should be smartly invested in the development of the renewable energy and diversification projects as well as host community projects (Oyebanji, 2022). The curtailing of gas flairing and environmental crimes would also provide governance and the identical accord that Nigeria signed in the Paris accord. A financial management reform will help Nigeria minimise the risks associated with oil price fluctuations and establish some viable avenues to a just energy transition.

Combining Surveying, GIS and City Planning Tools.

The drawback of the existing exploration governance is that it lacks spatial planning and tools to regulate the activities of hydrocarbons. It would make it possible to apply remote sensing technology, surveying, and GIS in real-time oil spill monitoring, pipeline networks, and land use change (Ayanlade and Proske, 2016). The system would make possible the process of decision making as far as environmental management, disaster management as well as infrastructural planning is concerned. Urban planning (e.g. zoning of areas to prevent the encroaching oil infrastructure on the delicate ecosystems, stricter environmental impact and assessment, consultative urban planning with the host communities etc.) requires an overhaul as well. They would be reacting to increased tensions in industrialization, the environment and urbanization in the Niger delta.

Development of Multidisciplinary Governance Framework.

The last one is sustainable geological exploration of the hydrocarbons that entails establishing a governing paradigm situated beyond the sectoral frontier in which the geophysics, economics, surveying, and urban planning become one policy. As the model of the current study indicates, disintegration based strategy is more prone to facilitate inefficiencies and frictions and that the cohesion on the higher levels could facilitate a balanced result in the growth, environment and society spheres. The inclusion of environmental, social and governance (ESG) clauses on petroleum contracts that guarantee that exploration activities are well in line with Sustainable Development Goals and the encouragement of consultations with different parties are all good steps towards that direction. Such a system would not only promote accountability, exploration of hydrocarbons in the Niger Delta would be oriented not only to national energy security, but also to climate on a global scale.

Conclusion

I had already said in my work that the study of the hydrocarbon in the Niger Delta could not at all be analyzed and discussed in the context of one discipline, but it was instead modelled as a multi-disciplinary one, and it was characterized by the following disciplines: geophysics, energy economics, surveying, and urban planning. A more non-invasive and civilized exploration rests on the technological foundation of geophysical advances in advanced seismic imaging and machine learning, though once again, the potential will be limited by how far Nigeria can go in building internal technical capability and institutional competence. The financial aspects are the historical susceptibility to a rentier economy - in all but a few cases based on renting oil, to accompany the financial reforms and energy transition strategies, in keeping with the Petroleum Industry Act (2021) and the international climate commitments as a signatory to the Paris Agreement. To a larger extent, space analysis deduces that exploration cannot be provided independently without surveying and GIS to regulate the system of monitoring oil spill, tracing pipeline and urbanization and urban planning systems are convenient to provide a means of estimating the industrial development in a stable environment and social stability.

Simultaneously, exploration in the Niger Delta is not only a question of institutional coherence, but also of participatory inclusiveness and long-term perspective, as it is discovered in the present work. The ideas in this paper have been formulated on the perception that energy security, climate responsibility and community wellbeing cannot be put up as a matter of catching up but rather on equal basis. Niger Delta is, in that regard, such a microcosm and a trial case of how the world will manage the problem of resource dependency and expectations of the sustainable and equitable society. In Nigeria the area of hydrocarbon exploration needs a formal cross-sectoral cooperation and resilience such that Nigeria is not evaluated by the location of petroleum but by the ability to be innovative and diversified and responsible in leadership.

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