

A Systems Thinking Approach to Validate the Dynamics of Environmental Degradation Issues: Evidence from the Nigerian Oil and Gas Industry

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Abstract

The paper focuses on all aspects of the numerous activities causing environmental degradation in the Nigerian Niger-Delta region, focusing particularly to the activities of the host communities and oil and gas companies using the systems thinking approach. The vast majority of the revenue that Nigeria's federal government receives from its oil resources is held by the Niger-Delta region. Numerous issues that affect the region, including as poverty, environmental damage, unemployment, and oil pipeline vandalism involving host communities and oil and gas companies. This paper aims to validate, in light of the current situation, the dynamics of environmental degradation issues involving host communities and oil and gas companies in the Nigerian Niger Delta. Consider the various ways that host communities' activities and oil and gas activity contribute to environmental degradation in Nigeria's Niger Delta. The paper used a systems thinking approach, which is necessary for capturing the involvement of host communities and oil and gas companies to environmental degradation in the Niger Delta. The Niger Delta's environmental degradation is the consequence of a complex relationship between oil and gas operations, host communities, and surrounding environments. ST is a qualitative technique that seeks to understand this relationship holistically. In order to convey unbiased insights and understanding of the environmental degradation as experienced in the Niger Delta, ST enables the application of Causal Loop Diagram (CLD) usage to capture the problem as a whole. The data collected from the literature review were analysed using computerised simulation software as Stella Architect®. It is also highly advised that an integrated and multidisciplinary research be carried out to examine this enduring issue in order to build a comprehensive plan and solution to deal with concerns related to environmental degradation and oil pipeline vandalism. Oil and gas companies have created a strategy to prevent environment pollution and treat waste before discharging it to minimize its effects in several locations around the world. However, similar methods are not widespread in Nigeria. In Nigeria, these methods must be adapted in order to preserve the already-degrading environment.

Keywords — Nigeria Niger Delta, Oil and Gas companies, Host communities, Environmental Degradation, Systems Thinking

1. Introduction

Nigeria's enormous natural resources, such as coal, oil, and limestone, which are used to boost the country's economy, are undoubtedly contributing to environmental degradation [1]. There are, however, a number of pollutants that are released into the atmosphere in Nigerian communities, including carbon dioxide, greenhouse gases, and global warming. As a result, there are sporadic oil leaks in the Niger Delta brought on by either oil firm operations or oil pipeline vandalism, which, if improperly controlled, has a detrimental effect on the economy of the country. These spills also result in fish fatalities, have an effect on people's lifestyles, and pose a number of health risks include asthma, pediatric respiratory issues, and unexpected death.

Despite the nation being blessed with a wealth of natural resources that are routinely taken by governments and multinational oil and gas firms [2], people in this region unfortunately nevertheless live in extreme poverty. This poverty is a result of the environment's continuing destruction, which makes it impossible for people to engage in traditional activities like farming. Due to the destruction from the oil spill, which has prevented the germination of crops on underutilised soil, the majority of farmers now struggle to pay for their children's education. Because of this, the price of basic goods like garri and cassava has increased, which might worsen hunger and extreme poverty.

Additionally, this led to an increase in unemployment because most farmers are unable to find skilled employment due to a lack of resources and unskilled jobs, which has led to economic stagnation, agricultural underdevelopment, and poor quality of life. Due to this lack of progress, militant organisations have appeared in the Niger Delta. They are attempting to manage the conflict by committing crimes like destroying oil pipelines and other misdemeanors in order to affect the locals and the Nigerian government's revenue [3]. This illustrates that a variety of variables, such as production-related spills, pipeline corrosion, poor infrastructure

maintenance, and intentional acts of oil vandalism, lead to environmental damage.

In order to address the research question: "How has environmental degradation influenced the socioeconomic structure of the Niger Delta region and recommendations that can successfully mitigate impact?" This paper explores how the Systems Thinking approach could be used to improve understanding of how to control and mitigate environmental degradation in Nigeria.

2. Conceptual Framework

Conceptual Clarifications of Environmental Degradation - The environment is weakened by human activity, which also causes biological systems to become extinct and the loss of natural resources, as well as contamination of the air, water, and soil. This process is referred to as environmental deterioration [4]. Additionally, it has the unsettling effect of being appropriate for harming the environment through institutional, social, financial, mechanical, and other activities, and it ultimately yields negative outcomes. Air pollution is more frequently the outcome of industrial operations since they create hazardous compounds including carbon dioxide, Sulphur dioxides, and nitrogen oxide.

In addition, pollution is any human-caused release of a material or energy into the environment, whether directly or indirectly, that endangers human health, harms ecosystems, devastates material assets, deteriorates amenities, or prevents other legitimate uses of the environment. Additionally, environmental problems and human activities are related [5]. This is so because every action a man takes has an impact on the environment, and those effects might be advantageous or harmful to him. People engage in a variety of activities.

These pollutants, which include noise, water, and air pollution, are produced by destroying the ecosystem. The regular environmental damage caused by oil spills and gas flaring by multinational oil firms has also been highlighted in a number of academic studies. A significant amount of the ecology in the Niger Delta has been seriously harmed by oil spills from oil and gas development. Significant portions of the mangrove forest, which provided the majority of the locals' wood needs, have been cleared, which has led to forced emigration, severe financial problems, health problems, social problems, political problems, and environmental problems throughout Nigeria, but particularly in the Niger Delta.

Types of Environmental Degradation- In general, there are three primary forms of environmental degradation, including air, water, and land degradation (also known as soil degradation);

Water degradation- Water contamination frequently comes from liquid discharges from manufacturing operations, decomposing waste materials, mining activities for solid minerals, as well as mining for petroleum. When harmful substances are introduced into bodies of water, the water can deteriorate and become dangerous for humans and animals to consume [6]. Most oil spills from tankers, ships, and offshore wells release waste products into different rivers and lakes that include poisonous compounds that can poison people, animals, or aquatic life.

Both human use of these substances and aquatic habitats are in significant danger. On the Nigerian coast, the Niger-Delta area is 80 percent covered by water. While the area was known for its nutrient-rich water lettuce and its pure, fresh, long-lasting water, which enhances the quality and favour of the soil, oil was discovered there. Oil and gas operations have polluted water in a number of occasions, and as oil production has grown so too has the frequency of oil spills.

Land Degradation- Drilling activities, for example, might harm the soil since they continue to be done, which encourages erosion and causes land degradation. These Explosive drilling operations can produce vibrations that pose a number of health risks and make the area unfit for usage or habitation [8]. The environment may also be harmed in a number of ways by issues including groundwater overdraw, land subsidence, and deforestation.

Tragically, oil and gas development in the Niger Delta region has decimated the region's huge mangrove forests, and biodiversity has been lost as a result of oil extraction, notably at terminals, slope regions, and flow stations. Increased access to woods has also sped up these illegal operations. For instance, 164 oil-produced fire flare-ups have occurred in the Niger-Delta region, including the Jesse fire event on October 17, 1998, which caused deforestation and the loss of crops. These fires, which also devastated crops and the environment, claimed the lives of over a thousand local residents of the oil-producing area. Because of the people's many complaints about the government's and foreign oil and gas companies' unfair resource allocation, which led to violence over oil in the region, this has been a continuing issue in the Niger Delta.

Atmospheric Degradation - The introduction of undesired gases, smokes, particles, and other compounds into the atmosphere is referred to as air pollution. Industrial activity is a major contributor to a variety of air pollution categories. Toxic pollutants such Sulphur dioxides, nitrogen oxides, and carbon dioxide are emitted by burning fossil fuels, operating vehicles, and operating thermal power plants. The environment and human health are now significantly

impacted by the increased air pollution caused by oil and gas operations in the area where the oil is produced. The atmosphere deteriorates as a result of the interplay between burning fossil fuels and producing organic contaminants. Breathing may have been difficult due to the air pollution, which may spread disease, attract insects, and attract animals [9]. Furthermore, gas flaring, a common practise among oil and gas companies in Nigeria, particularly in the Niger-Delta region, pollutes the air, puts the region's surface layer at risk, and accelerates climate change. The 45.8 billion kilowatts of heat created, on the other hand, continually warm the Niger Delta's atmosphere. It is clear that gas flare-ups in the region have had a negative impact on the ozone layer, generating an unfavourable alteration in the atmosphere that impedes agricultural development. Gas flaring is clearly exploitative, and it has had a severe detrimental impact on the local ecology. Because air pollution has altered the surrounding vegetation, rough grasses have taken their place. These tough grasses indicate that the crops demand extra fertiliser.

3. Oil and Gas Company in Nigeria

Since the discovery of oil at Oloibiri in 1955, Nigeria has had access to a plentiful supply of crude oil, with sales of that product accounting for roughly 90% of the government's overall revenue, 80% of the GDP, and 95% of the national budget [10]. This demonstrated how heavily reliant the Federal Government of Nigeria's (FGN) economy is on crude oil. Nigeria's oil and gas sector, which continues to be a significant source of foreign direct investment (FDI), is being developed with billions of dollars invested by oil and gas corporations (OGCs). There are ongoing worries about the sustainability of OGC procedures since they frequently produce significant environmental damage [11].

Even though the country receives a sizable portion of its income from crude oil, relevant industries have not grown, particularly in the Niger Delta. Given that the indigenous population's capacity to exist has been wiped out by decades of crude oil-related activity, this is unacceptable. The OGCs argue that governments should support these areas regardless of their moral obligation to assist those whose acts endanger their ability to live normal lives. The most frequent ways oil company activities harm the environment are natural catastrophes and gas flare-ups. Oil spillage, which creates major economic, ecological, health, social, and political difficulties for Nigeria in general and the Niger Delta in particular, is the principal environmental issue associated with crude oil exploitation in the Niger Delta.

Significant soil pollution results, which affects both aquatic and terrestrial life. As seen in Table 1, sabotage, equipment breakdowns, and operational mistakes are all possible sources of spillages from

Nigeria's oil and gas operations. In the West Niger Delta, for instance, a storage facility at the Shell-run Forcados port fell in 1979 and released more than 560,000 barrels into the environment. Over the course of Nigeria's 40-year oil exploration history, 6,000 spills were also documented there. This demonstrates a high level of exposure to contaminants and an annual average of 150 throughout this time. In contrast, gas flaring refers to the combustion-based burning or disposal of waste gases. In the Niger Delta region, most gas flaring occurs in proximity to oil wells that are close to farmland and populated areas.

Table 1. Nigeria Industrial Oil and Gas Industries and Environmental Impact [23]

Nigeria Oil and Gas Industries	Industrial Operations	Potential Risk to the Environment	Environmental Impact
Warri Refinery and Petrochemicals, Kaduna Refinery	The refining of petroleum products	The discharges through transportation vessels	Air emission, accidental discharges, operational failure, polluted soil and sediment, and disposal of sanitary waste, etc.
Total Nigeria Plc, Texaco Nigeria Plc, Mobile Oil Nigeria, Oando Oil Plc.	Marketing activities: production, importation and storage	Operation discharges and waste disposal	Oil spillage : contamination of the soil and sediments, emission of organic pollutants and environmental problems
Shell (SNEPCO), Shell (SDFCA), Agip Oil Company, Mobile Production Nigeria (unlimited), Conoco Petroleum, ELF Petroleum Nigeria	Development and Production: development of drilling processing, separation and treatment, initial storage	Discharges of effluents (gases, liquid, etc) Operational discharge Atmospheric emission Noise pollution Transportation problem Socio-economic /cultural issues	environmental destructions and interference: pollution of soil and sediment with oil derived waste, gas flaring/venting, environmental pollution, ecological issues in the host communities, adverse health implications, etc.

Environmental Degradation and Oil and Gas Companies' Activities: The following are environmental degradation from oil and gas activities listed below;

Impact of Drilling Discharges- Since its discovery, oil has significantly harmed the environment due to outdated infrastructure and petroleum equipment. Figure 1 shows how oil may flood host communities during oil drilling operations and how hazardous drilling waste from hydrocarbons may flow into freshwater ecosystems [12]. They might be released into the environment, particularly in the Niger Delta, which would be extremely harmful to the ecosystem and people's health, possibly leading to an increase in cancer cases, respiratory infections, blood diseases, etc. As a result, the federal government is facing more complaints about oil and gas activities.



Figure 1. Produced water discharged to surface water [22]

These might be the consequence of unintentional discharges or even human mistake. Wastes generated during exploration and production also include air emissions, drill cuttings, drilling fluids, deck drainage, and well treatment fluids in addition to accidental oil spills as seen in Figure 2. Oil-related environmental problems are widespread in the Niger-Delta area and have a wide range of effects on people's economic and social well-being. These negative repercussions include a high unemployment rate that has sparked hostage taking, violence, and other problems. In the communities where some of these investments were made, these industrial operations—which had the potential to harm the environment and pollute it—were carried out in an uncontrolled manner, which led to the deterioration of health standards, contamination of water supplies, and destruction of traditional economic infrastructures.



Figure 2. Accidental oil discharged [22]

Impact of oil Transportation- Pipelines, tankers, railroads, cargo ships, and refineries may transport Petroleum Transportation Impact- oil. However, each of these routes has the risk that oil will leak and negatively influence the environment, such as by causing air pollution, as shown in Figure 3 [13]. Regardless of the mode of delivery, oil spills may significantly affect the economy, the environment, and human health.

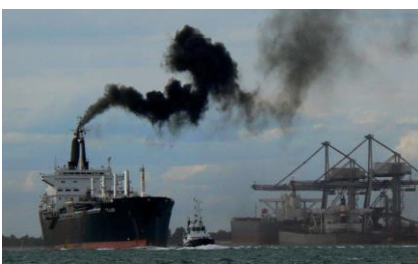


Figure 3. Air pollution by a cargo ship [13]

As shown in Figure 4, a number of factors have led to environmental deterioration in the Niger Delta area, including equipment failure, inadvertent discharge, oil spills from storage tanks, spills brought on by ageing equipment, and operational difficulties because of oil and gas activities.



Figure 4. Corroded pipeline in the host communities [13]

Table 2 demonstrates how a way of transporting crude oil may expose people to crude oil that has been spilled during oil and gas firms' commercial operations. The historical incidence of sore eyes, rashes, and industrial injuries are much greater due to this influence, which is extremely hazardous to human health. This clearly shows that the residents of the oil-producing villages have been exposed to crude oil through these operations by Nigerian oil and gas corporations, resulting in infertility, hemotoxicity, hepatotoxicity, and carcinogenesis.

Table 2. Symptoms by Crude Oil exposure [17]

Oil Exposure	Short-term Symptom after oil exposure	Long-term Symptom after oil exposure
1) Benzene	1) Memory loss	1) Increased cancer risk
2) Sulphur	2) Headache	2) Reproductive problem
3) Nitrogen	3) Chest pain	3) Decreased immunity
4) Xylene	4) Skin Injuries	4) Lung problem
	5) Eye Sores	5) Heart issues
	6) Rashes	6) Liver problem
	7) Vomiting & Nausea	

Gas Flaring and Venting - In advanced countries, gas flaring and oil to gas venting are considerably less of a problem, although they still exist in underdeveloped nations. Burning associated gas can harm people's health and worsen air pollution. This is true because it emits harmful heavy metals, carbon monoxide, carbon dioxide, and other air pollutants [14]. Among the petroleum chemical types that are burned off as petrol and released into the environment are butadiene, ethylene, propane, and propylene. As can be seen in Figure 5, the residents of the oil-producing region are currently experiencing major health issues because of the gas flaring emissions. 40% of the natural gas consumed in Africa each day, or around 70 million /m3, is flared in the Niger Delta area.

Nigeria has the highest record (19.79%) for natural gas flared per tonne of oil produced and accounts for 46% of all gas flared in Africa. The majority of greenhouse gas emissions come from just this one source.



Figure 5. Gas Flaring into the Oil Producing Communities [14]

4. The Niger Delta Host Communities of Nigeria

The Niger Delta region, which encompasses 185 local government areas (LGAs) in nine states, including Bayelsa, Akwa-Ibom, Edo, Imo, and Delta, among others, has the highest concentration of freshwater wetlands. Even though oil pipeline vandalism forced 25% of oil production to cease, the region's overall revenues still made up 95% of all of Nigeria's foreign earnings and more than 80% of government income [15]. The destruction of host communities' means of sustenance was not, however, a worry that was voiced by either the government or the oil firms.

Unfortunately, this has changed the way that young people think and resulted in a militarization that has increased crime and attacks on oil installations in the area, drawing attention from the government and the oil industry to the precarious situation of the Niger Delta communities. In comparison to the money from crude oil sales and the degree of landscape destruction, which has also resulted in the creation of militancy and environmentally harmful oil pipeline vandalism, it is believed that the statutory 3% contribution to NDDC for community development is insufficient.

Environmental Degradation and Niger Delta Communities Activities: The activities of the oil-producing communities in the Niger Delta listed below contribute to environmental degradation:

Vandalism of pipeline: Figure 6 illustrates how pipeline sabotage and other acts of vandalism have significantly deteriorated the environment in the Nigerian Niger Delta region through a variety of related crimes. Due to the blazing flame and smoke from the oil pipelines, this region frequently has fire breakouts, which emit significant amounts of gaseous chemical pollutants such as carbon dioxide and nitrogen oxide [16]. 75% of the population is extremely poor, between 50% and 55% of urban inhabitants lack access to clean water due to environmental degradation, 73% of city dwellers use firewood as their primary energy source, and only

34% use electricity as a source of energy when it is available.

Vandalism of oil pipelines has increased in Niger Delta areas because of inadequate infrastructure. The issue of persistent neglect of rural areas is seeming dearth of basic infrastructural amenities include the development of previously unheard-of rural settlements because of lowered food security and growing rural population. By resorting to desperate tactics to meet their needs for basics such as food, water, and shelter, these host communities have put further pressure on the safe areas. In the Niger Delta, leaky pipelines that pass through farms, villages, creeks, and rivers are a major source of pollution, sickness, and economic disaster for the locals.

Numerous small-scale oil spills added together can be just as hazardous to the area in question as a single large oil discharge. Without a question, the Niger Delta's oil spills and gas flare-ups have made it more challenging for endangered species to survive. This caused a dispute over environmental degradation between the host towns and oil and gas firms.



Figure 6. Vandalism of oil pipelines In Niger Delta Region [15]

Illegal oil bunkering: Figure 7 illustrates how oil bunkering, which is the theft of oil for personal benefit by unauthorised individuals, groups, or organisations, becomes a crime [17]. The primary motivation behind these militant groups is the aim to steal petroleum goods, with the ultimate goal of undermining both the security measures of the federal government as well as significant multinational oil and gas businesses.



Figure 7. Illegal Oil Refinery and Affected Drinking Water by Oil [17]

As can be seen in Figure 7, communities of the Niger Delta are becoming more and more dependent

on drilling water boreholes to acquire high-quality drinking water because the water is contaminated with the oil and causes a number of health issues. The militants' acts, such as illegal oil bunkering, are meant to draw attention to the government's failure to live up to their expectations and to their demands for social, environmental, economic, and political justice. Inadequate agricultural output, a high societal discount rate, and long-time horizons for the impoverished, all contribute to the unwelcome trend of illicit oil bunkering.

On the other hand, it is also asserted that Nigeria's recent poor agricultural production is due to deteriorating farmlands, a feeble government agricultural support programme, rising water pollution, and climate change. As many other nations, Nigeria has a large proportion of rural population who heavily rely on the usage of fuel wood for their residential and sometimes commercial energy requirements, numbering over 70%. Vandalism of oil pipelines has arisen because of the government's incapacity to address this fundamental need.

5. Socio-Economic Consequences of Environmental Degradation

As a result of the aforementioned activities, this section focuses at how environmental degradation affects the social and economic well-being of Niger Delta residents:

Economic Consequence of Environmental: The following economic consequence of environmental degradation in the Niger Delta region are identified:

High Level of Unemployment Rate: unemployment is a problem in the Niger Delta. It is arguably the biggest contradiction in history that the country produces wealth while more than half of its citizens are living in poverty. This indicates a great deal about the job climate in the area as well as the potential for personalised economic empowerment. It is unsettling to learn that business organisations have not created backup plans to introduce the idea of social responsibility to host communities through educational initiatives and other projects that will empower and increase the chances for young people in the host communities to engage in the economy. Farmers and fishermen make up the bulk of the jobless population. As a result, oil pipelines have been vandalised [18].

The locals who participate in the oil pipeline vandalism are highly educated and skilled, but they decide to engage in other criminal activity to make ends meet due to their unemployment. As things stand, the commencement of oil production in the Niger Delta is more beneficial to the oil and gas

industry and the federal government than the loss of indigenous well-being induced by the destroying of farmsteads. Due to the loss of farmsteads caused by oil drilling and spills, which forced peasant farmers to relocate to less populated regions, the rural peasant economy of the Niger Delta faced significant unemployment. Environmental stress and unemployment are the results of this.

High Level of Poverty Rate: environmental degradation has a significant impact on people's ability to engage in professional occupations including farming and fishing in some regions of the Niger Delta. In order to live, some communities have demonstrated by breaking oil pipelines. This has caused poverty to become a way of life, which has resulted in the community economic stagnating, unemployment, a lack of healthy food, a poor standard of living, and unfavourable environment [19]. Despite Nigeria's riches ushered on by its oil resources and reliance on subsistence farming and regional commerce, rural poverty still exists there. This is clear from the difficulty many people have meeting their fundamental necessities for food, water, and shelter. Inadequate access to these necessities has hampered rural development in Nigeria.

The host communities' over reliance on protected areas, particularly in relation to non-timber forest products, is the result of this one cause. Because poverty is so pervasive and has so many detrimental effects on society, the government is adamant about using a multifaceted approach to stop the rise of poverty in Nigeria. The government established the National Poverty Eradication Council (NAPEC) to coordinate the initiatives taken by the various parastatals, ministries, and agencies to combat poverty. It is possible that the representation in the Paradox of Poverty, which examined the connection between poverty and population growth, and the failure of Nigeria's effort to eradicate poverty, which are not wholly unconnected.

This also holds true for Nigeria's Poverty Alleviation Programme, which, whether on purpose or not, has widened the wealth-poverty divide. The policy is allegedly linked to particular initiatives that would assist the poor live prosperous lives, but virtually always, the funds meant to fight poverty has been used to support and maintain political party patronage.

Loss of Revenue: The Niger-Delta pipeline vandalism activities have endangered the environment and threatened the Nigerian economy in a number of ways, including by substantially lowering tax revenue [20]. Damage to oil pipelines makes it more difficult for the federal government to raise the funds needed to fulfil its responsibilities to ensure the safety of its citizens since revenue will be lost. The more the oil pipeline damages the environment, the

more revenue the government loses. Over the years, the government has attempted to find a solution to this problem, which has not been successful.

Social Consequence of Environmental Degradation: Environmental degradation in the Niger-Delta region has societal consequences that are being pursued:

Hostage Taking, Conflict, and Youth Anxiety: Conflicts between host communities and oil and gas companies, as well as between the government and host communities, can range from intra-community to inter-community. As a result, they may lead to the explosion of an oil pipeline. A rise in the region's politics and economy has also resulted in a number of hostage-taking incidents [21]. More specifically, the terrible conditions like juvenile violence, conflict, antagonism, and anxiety are brought on by the region's persistent poverty and unemployment.

There is a pervasive sense of unfairness and inequity, particularly among minority ethnic groups that have established a variety of paramilitary units to counter the opportunistic goal of the federal government and its international allies. In this regard, the Niger-Delta area has to be highlighted since it has grown into a centre of youth activism and unrest that petroleum industry activities have mostly been able to suppress.

With relation to their desperate criminal situations, these Niger Delta youths have very little alternative except to endure verbal abuse. They have gone too far in their desire to seek retribution on oil and gas companies that violate approved environmental standards, as evidenced by tales of expatriates being kidnapped, oil pipelines being vandalised, or even the murder of oil workers by enraged youths.

Unfriendly correlation between the oil producing communities and oil companies: The Niger-Delta region's ongoing environmental degradation has hampered relations between the foreign oil and gas corporations that operate there and the indigenous host people that generate the region's oil [22]. The host communities would have trusted the oil and gas firms before they started their activities, and they would have maintained their commitments to those communities. Oil and gas firms have frequently failed to meet the expectations of the host communities over time, which has resulted in these confrontations over land settlement. Despite disagreements over the precise amount, oil and gas companies were required to repay compensation.

Health Risk Issues: The ecosystem is negatively impacted by routine hydrocarbon emissions into the soil, which might also expose people to dangerous chemicals [23]. This exposure might lead to

chromosomal problems, skin tumours, poor bronchial development in babies, and skin damage, all of which could have long-term implications on the respiratory system. In addition, many Niger Delta locals who lived near oil and gas operations are quite likely to have many horrible side effects, such as stunted growth, strange behaviour, subpar physiological responses, respiratory problems, and cancers of various organs, etc.

There has been a rise in carcinogenic diseases because of oil spills, notably the impact of gas flaring on Niger-Delta populations, which can be attributed to their exposure to radioactive elements from gas flaring. Due to their lengthy exposure to gas flares, these people develop respiratory problems. Cancer-causing conditions including skin and lung cancer appear to be on the rise in the Niger Delta.

5. Methods

The paper intended to validate the dynamics of environmental degradation Issues in Nigerian oil and gas industry (Niger Delta Region) using the Systems Thinking Methodology (STM) proposed by Forrester and Olaniyi [24] and [25]. The study, which explores the issue of environmental degradation, caused by the oil and gas companies and the host communities in Niger Delta regions where oil was first discovered. The exploratory approaches would be used due to the complexity of the research and to give an in-depth comprehension of the problem as it pertains to oil spills and gas flaring. Systems Thinking (ST) approach will be adopted because it focuses on the interactions of components of dynamic systems within complex problems.

ST is a qualitative approach that makes use of the individual's mental model to capture various interactive behaviour while looking at a complex problem. In order to inductively develop the CLD (casual loop diagram) of the systems interactions, data will be collected from journal articles, online archives, reference books on issues related to oil and gas activities and host communities of the oil producing region. Casual Loop Diagram (CLD) is a Systems tool used to illustrate a feedback loop in an explicit diagram (As shown in Figure 9). This shows the different behaviour leading to the environmental degradation such as drilling discharge by the oil and gas activities or oil pipeline vandalism by the host communities.

In the process of CLD, involve the use of feedback loops, and this feedback loop either balancing (negative) or reinforcing (positive), which is the fundamental building component of all systems [24]. The causal loop diagram provides a high-level approach of conceptualising models on the basis of their feedback loop structure of presentation of expression of the causation relationships between different variables. There are six steps of STM as

indicate in figure 8 adopted by [24] to provide a clear understanding of a system structure are problem definition, system structure conceptualization, mode formulation, mode stimulation, policy analysis and model results and finally, policy formulation and implementation.

Using STELLA STM software to analyse the dataset, a model was developed to validate the dynamics of how the host communities and the oil and gas industries contributed to environmental degradation in Nigeria Niger Delta. Utilizing the ST approach as a framework is justified by the fact that it captures the system from a holistic point of view as opposed to the more conventional static point of view.

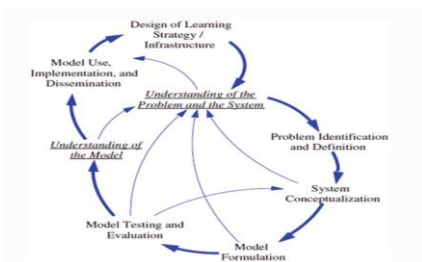


Figure 8. The Phases of Systems Thinking and System Dynamics [25]

6. Discussions and Analysis of Issues of Environmental Degradation in Nigeria Niger Delta

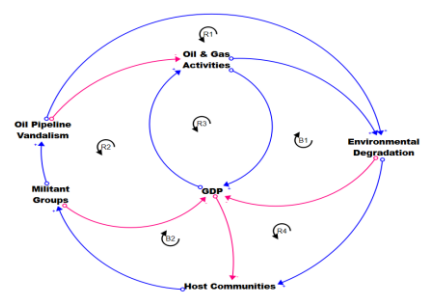


Figure 9. High Level Map of Causal Loop Diagram of Environmental Degradation in Nigeria Niger Delta

According to the high level map of the Casual Loop Diagram (CLD) above, sub-systems such as oil and gas activities (R2) and host communities (R1) will be discussed. The purpose of this paper is to validate the dynamics of environmental degradation Issues in Nigerian oil and gas industry (Niger Delta Region) which involves the roles that oil and gas companies and host communities play in contributing to environmental degradation. The interpretation of the oil and gas activities loop (R2) describes the capacity of how the oil and gas operations have resulted to environmental degradation such as drilling discharge,

accidental discharge, equipment error etc., even although, it has generated huge revenue (GDP).

In figure 9 show the relationship of R2 that the oil and gas activities increase to generate more GDP, environmental degradation that in turn increase the host community's dispute, and further lead in an increase in militant groups due to the impact of environmental degradation on their livelihood, then lead to oil pipeline vandalism to make ends meet. As oil pipeline vandalism increases, it will further lead to reduction of the oil and gas activities. The interpretation of the host communities loop (R1) also describes how the host communities' dispute emerges as result of increase in poverty, unemployment, constant degradation of environment, displacement of occupation and livelihoods, etc.

As outlined in Figure 9, in order to improve the understanding of the feedback loop of the host communities describes that a rise in host communities' disputes because of environmental degradation from the oil and gas activities has the potential to enhance the rate of militant group. An increase in militant's groups will lead to an increase in oil pipeline vandalism (the increase in militant groups will lead to an increase in unlawful activities such as illegal bunkering). Increased in oil pipeline vandalism will now have a greater environmental impact, which will increase the level of environmental degradation. These interactions produce a variety of dynamics and complexity that call for deeper comprehension.

Although the oil and gas activities and host community's module are different sub-systems, it can be seen that the oil and gas companies must address the unintended consequences of environmental degradation and oil pipeline vandalism in order to reduce host communities' dispute because oil and gas activities are the catalyst for oil pipeline vandalism (an unlawful act). Figure 9 also illustrates the consequences of the government's lack of focus on maximising development and equitable distribution, resource conservation, and sustainability. These consequences need to be addressed.

7. Conclusion

The Niger Delta's susceptibility to a range of environmental problems, including as environmental deterioration and spills, is associated with a rise in oil and gas operations, improper drilling waste disposal, and noncompliance with environmental safety rules. These led to a rise in hazardous levels and the effects of these wastes on the environment result in stunted plant growth, the extinction of aquatic life, disturbances of human health, etc. When harmful metals like iron, manganese, chromium, copper, and other elements are released into the environment, it can cause cancer, neurological diseases, and other issues. These results demonstrate that oil and gas

operations' unintentional spills, malfunctioning machinery, and operational errors all contribute to environmental damage.

Host communities have directly suffered different illegal activities including oil pipeline vandalism because of the Niger Delta's problems with environmental degradation, unemployment, and poverty. Consequently, there is still animosity between the local populations and the oil companies. The federal government or international oil companies have remedied none of these problems. The consequences of this government carelessness were also seen in the Niger-Delta area, where continued oil extraction and the resulting environmental difficulties garnered worldwide attention. Since environmental concerns were initially ignored in oil exploration planning and funding, this area has high levels of environmental contamination.

Nigeria's oil sector has a significant pollution load, largely because of inadequate or nonexistent environmental legislation and a lack of political will to enforce present standards. People whose land is used to extract and produce crude oil are ignored because the Nigerian government depends on the income from the lucrative industry. The indigenous population and the oil prospecting companies are at odds. The management of the well-known firms lives in a pleasant environment (with access to power, quality healthcare, a steady supply of water, etc.), but their host communities do not.

Gas and oil leak because of this sabotage. The saboteurs carry out these activities for their own benefit or to "retribution" the oil and gas companies and the federal government by requiring them to reimburse the communities that produce oil. Such sabotage would have unimaginable consequences since the ecosystem would have already degraded irreparably.

8. Recommendation

It is strongly recommended that multidisciplinary research be done to address this ongoing problem in order to develop an all-encompassing strategy and solution to address issues with environmental degradation and oil pipeline vandalism. To encourage the Niger Delta oil and gas firms to fully engage in more socially responsible activities, the government must address concerns like providing some basic facilities, scholarships, and sponsoring philanthropic events. This will significantly lessen the tension and militant agitations that have grown commonplace in the region.

In order to ensure long-lasting peace, greater oil production revenue, and economic expansion, the Federal Government should also implement the insurgent development initiatives and agreements reached by Niger-Delta leaders. Oil and gas firms have implemented measures to lessen environmental

deterioration and treat waste before releasing it into the environment in certain nations throughout the world, but in Nigeria, such tactics are unusual. Therefore, these tactics must be modified in Nigeria in order to protect the environment, which is already declining.

9. Contributions to Knowledge

The study adds two new insights to the body of knowledge. Firstly, the study contributes to a better understanding of the ramifications of oil and gas companies' and host communities' participation in environmental degradation in Nigeria using the Niger Delta Region as a case reference. Secondly, the study identifies vandalism, poverty, and militancy, conflict, lack of infrastructure, unemployment, and unequitable distribution of resources as crucial determinants affecting the Nigerian economy.

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