Sustainable management of Mineral Resource Active Regions: A Participatory Framework for the Application of Systems Thinking

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Declaration of Originality

I declare that this thesis, ‘Sustainable management of mineral resource active regions: A participatory framework for the application of systems thinking’, is entirely my own work and that where any material could be construed as the work of others, it is fully cited and referenced, with appropriate acknowledgement given.

Copyright Declaration

Abstract

Mineral active regions (MARs), considered here as those with stocks of geological resources of intrinsic economic interest that can be used beyond the scope or need of the local people, have undergone decades of extraction with significant environmental and human health effects, socio-cultural impacts, and ecosystem and biodiversity consequences. Traditional resource governance and management approaches were reviewed and the potential for re-assessing these regions from a systems perspective was investigated. Through an extensive review, the application of systems thinking in resource management was demonstrated to have the potential to deliver benefits to all stakeholders while maintaining ecological integrity. Rather than simply relying on competition, a process that focuses on the interdependencies between the various players and sectors in these regions can deliver system improvements and should be further investigated because of its potential to deliver holistic solutions that could benefit all involved. Appraisal of systems methodologies was undertaken and their application to MAR challenges discussed, and a participatory approach was selected to form the basis of the proposed framework, a holistic tool to deal effectively with the complexity of MARs. Using a case study, the thesis addressed the data required to capture its complexity and catchment information, policy problems as well as relevant stakeholders were identified. A participatory group building process was conducted which was a learning process that resulted in the co-production of knowledge by identifying problem drivers in the region. Quantitative data on a decade of oil spill was analysed with graphical representation showing the causes of oil spill, quantity spilled and lost to the environment. The result of the data analysis supported the outcome of the participatory process which links the problem drivers with underlying socio-economic problems plaguing the region. The application of the participatory framework in the case study demonstrates the practicability of the tool and how it can be utilised to see the interactions and interdependences between actors and elements in the MAR system. Understanding the full consequences and benefits of such interactions was shown to be the way to avoid conflicts and encourage collaboration. The participatory systems framework developed here can facilitate the sustainable management of MARs based on its inclusive approach. It can serve as a tool to support policies that ensures that resource development is undertaken sustainably through a resource regime that is able to deliver benefits to all stakeholders involved.

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Dedication

This piece of work is dedicated to God and my Lord and Saviour Jesus Christ for the blessed opportunity and enablement to pursue my education to a doctorate level and being my guide and strength throughout my research.

Acronyms and Abbreviations

- BTEX: Benzene, Toluene, Ethylbenzene, Xylene
- CO_2: Carbon dioxide
- DPR: Department of Petroleum Resources
- DPSIR: Drivers–Pressure–State–Impact–Response
- EDI: Extractives Dependence Index
- EEA: European Economic Area
- EIA: Energy Information Administration
- ES: Ecosystems services
- FMOE: Federal Ministry of Environment
- GDP: Gross Domestic Product
- GHG: Green–House Gases
- GMB: Group Model Building
- IPCR: Institute for Peace and Conflict Resolution
- IYC: Ijaw youth Council
- MAR: Mineral Active Region
- MCDA: Multi-Criteria Decision Analysis
- MEA: Millennium Ecosystem Assessment
- MEND: Movement for the Emancipation of the Niger Delta
- MMSD: Mining, Minerals and Sustainable Development
- MNOC: Multinational Oil Companies
- MOSOP: Movement for the Survival of the Ogoni People
- ND: Niger Delta
- NEITI: Nigeria Extractive Industries Transparency Initiative
- NGO: Non-Governmental Organisations
- NNPC: Nigerian National Petroleum Corporation
- NOSDRA: National Oil Spill Detection and Response Agency
- OCDE: Organisation for Economic Co-operation and Development
- OPTS: Oil Producer Trade Section
- PAH: Polycyclic Aromatic Hydrocarbons
- PANDEF: The Pan Niger Delta Forum
- SA: Systems Approach

- SA: Stakeholder Analysis
- SDM: Systems Dynamics Model
- SESs: Social-Ecological Systems
- SPDC: Shell Petroleum Development Corporation
- S-RESS: Stress-Response Environmental Statistical System
- SSM: Soft Systems Methodology
- ST: Systems Thinking
- UNDP: United Nations Development Report
- UNEP: United Nations Environmental Protection
- VOC: Volatile organic compound
- WBG: World Bank Group
- WEC: World Energy Council
- WRI World Resources Institute

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Chapter 1

"For every complex problem there is an answer that is clear, simple, and wrong."
H. L. Mencken

1 Introduction

The natural environment provides vast resources; renewable and non-renewable (Asafu-Adjaye, 2005). Almost 3.5 billion people live in 56 resource-rich developing nations in which minerals (sub-soil assets) account for more than half of export earnings (Khoday & Perch, 2012), with annual global investments reaching $1 trillion and estimated resource rent of about $4 trillion annually or seven percent (7%) of global GDP (Barma et al., 2012). These natural resources are available in the ecosystems continually exchanging matter and energy with their environment (Currie, 2011). The components of natural-resource assets found in our natural environment are complex and have both intrinsic and synergistic value because of their relationship and interactions. Ecosystem resources found in the environment can be broadly categorised as biodiversity and geodiversity (Da Silva, Everard, & Shore, 2014; Gray, Gordon, & Brown, 2013) from which we derive minerals, energy, water, food and biochemicals which provide sustenance and form the basis of many economic activities. Natural mineral resources have served as a foundation for human development and modern civilization: their extraction and end products are the driver of the unprecedented development and prosperity the world has experienced over the past century (Bridge, 2004; MMSD, 2002), with complex linkages between extraction and society (Spitz & Trudinger, 2008). For many regions of the world, the exploration and exploitation of mineral resources (geodiversity) is a major source of economic growth through foreign direct investment and generation of gross domestic product (GDP) thus providing foreign exchange earnings while for others, renewable biological resources are key to economic sustenance. Minerals and energy resources constitute the bulk of the exploited mineral resources for most economies of the world. These resources found in natural ecosystems constitute part of the 'ecosystem capital' that provides subsoil assets, abiotic flows and ecosystem goods and services (Gray et al., 2013). The extraction of mineral resources disturbs the natural environment and has had devastating effect on human and ecosystems' health. Species are disappearing at a fast rate due to fragmentation, degradation, and outright loss of forests, wetlands, and other ecosystems. Many of these episodic events caused by human impacts have been associated with extractive activities (Khoday & Perch, 2012; Punam et al., 2015). Global natural capital is declining due to cumulative exploitation. The interactions and effect of exploitation on social and economic components generates a complex system interaction which is difficult to manage. For example, the realisation of the potent threat of anthropogenic impacts on biological diversity led to the formation of Convention on Biological Diversity (United Nations 1992). Biodiversity is a multi-dimensional construct that expresses biological diversity. In biological science context, diversity introduces complexity at different scales such as genes, species, and ecosystems (Lister, 1998; NRC, 1999). The word biodiversity has discipline-oriented understanding and could mean different things to different people. However, it is a term widely used in the field of ecological science and has gained prominence in both political and environmental domains. The components of biodiversity—genes, species, and ecosystems supply the society with a myriad of goods and services. Therefore, a change in biodiversity would affect the ecosystem goods and services that society directly or indirectly receives from nature.

Geodiversity is the geological equivalent of biodiversity and describes abiotic (non-biological) aspects of nature in terms of geological, geochemical and geomorphological features (Gray et al., 2013). The geological features include the rocks, minerals, fossils, whilst the geomorphological features are characterised by landforms and processes. It is an integral part of the natural capital that is depletable and non-renewable. Besides the provision of mineral and energy resource, it provides supporting, regulating and cultural services (Gray 2011; Gray et al., 2013). They are repositories of the non-renewable resources wrested from the earth (Bridge, 2004) and the basis for the mining and mineral industry extracting energy, metallic, construction and industrial minerals of which their extraction is transformative of the host environment. The stocks of resources derived from geodiversity have been built/formed over extended geological time scales and constitute the basis for classification as non-renewable because they are difficult to renew within human timescales (Prior et al., 2012) and their exhaustion would limit human development since they constitute the raw materials and energy resource on which the global economy is based upon.

Extraction of geological resources creates environmental problems due to complex interactions as seen in mineral rich regions (Bridge, 2004; MMSD, 2002). For example, human impact on the natural environment has occasioned unprecedented increase in biodiversity loss, vegetation and landscape changes, economic inequality, greenhouse gas emissions/climatic impacts and unrestrained resource consumption (Kindzierski 1999; Kuemmerle et al., 2014) and therefore underscore the need for the integration of a practical nexus between geodiversity and biodiversity (Gray et al., 2013). The gradual decline in the natural resource base coupled with environmental degradation arising from mineral extraction in regions where extractive activities overlap biological rich and sensitive areas is a complex problem pushing the limits of sustainability of these natural assets. These environmental and natural resource problems are familiar but are complex, uncertain, chronic and defy traditional thinking that does not take cognisance of systems delays, feedbacks and interactions across space, time, and multiple actors. Interactions between biotic and abiotic components of the ecosystem naturally occur, however, anthropogenic interventions have magnified these interactions, exerting pressure on natural systems. Therefore, integrating the trade-offs of the interaction between geodiversity and biodiversity especially due to extractive activities is a holistic approach to conservation and management of our ecosystem's resources so as to support a broad-based environmental policy that is able to deliver economic, social, cultural and environmental benefits for society (Gordon & Barron, 2011). Propelled by recognition of anthropogenic impacts such as fragmentation and ecosystems degradation as well as the growing interest in sustainability/sustainable development, biodiversity and ecosystem integrity (Slocombe, 1998); integrative management of the impacts of industrial process (such as extractive activities) on natural ecosystems through a holistic approach has gained increased momentum. Several management approaches including governance regimes have been advanced such as the Integrated Resource Management (IRM) Pahl-Wostl (2007) with focus on the social, economic, technical and institutional programs to ensure a robust resource management outcome. The Ecosystem Approach (Gordon et al., 2012; Slocombe, 1998); describes environmental systems and their interactions between biotic and abiotic components and associated ecosystem services to promote conservation and sustainable use. The integration of biodiversity, geodiversity and associated socio-economic variables in management has been advocated to ensure sustainable development through informed policy design (Gordon et al., 2012; Gray et al., 2013; Van Ree & van Beukering, 2016).

This is important because many regions of mineral wealth for example the Niger Delta (ND) Nigeria, the Cabinda region of Angola, Chaco Region of Bolivia, or the Pascua–Lama of Chile have borne the wrath of decades of extractive activities whilst left with little benefits from the gains accruing from extractive processes along with legacy socio-economic and environmental problems (Eregha & Irughe, 2010; Jike, 2004). The problems in these regions are complex and attempts to manage them have be generally unsuccessful. Many of the conventional approaches to management have been sectoral, discipline based, command and control inclined, and mostly short-term profit driven failing to address the complexity of these interactions and therefore reductionist. These reductionist approaches are lacking in multi-disciplinary perspective and are consequently limited. Understanding the complexity of mineral resource extraction in these regions is key prerequisite for resources management to be more effective and sustainable.

The study proposes systems thinking as a holistic and transdisciplinary tool that supports the management of activities in mineral extracting regions; looking at different scales, structure, process, and function to deliver the systems purpose. Systems thinking is critical in the management of complex and unstructured problems such as those witnessed in mineral extracting regions arising due to multiple actors, interest, and interactions. This thesis investigates the potential of systems thinking as a holistic tool to effectively deal with complexity of mineral active regions and developed a management framework that is broad-based and inclusive with the aim of its application supporting the sustainable management of mineral resource regions. The framework was applied to a case study — Niger Delta Nigeria, a region that hosts about 5% of global oil and gas reserves (Nduka et al., 2008; Nduka et al., 2012), regarded as one of the world's richest crude oil tertiary deltas and plays host to both marine and terrestrial biodiversity. The framework developed in this study is a generic tool that is flexible to be adapted by policy makers and resource managers to support management.

Chapter 2

2 BACKGROUND

2.1 Introduction

Mineral and energy resources are indispensable to the running of the modern industrial society. They provide the foundation for sustained economic growth. These resources affect every part of people's day-to-day life as they are economically and socially dependent on them (Moran et al., 2014; Prior et al., 2012). Many regions around the world host different subsoil resources and their extraction have created legacies of social and environmental challenges such as: environmental degradation and sustainability issues and open debates on development pathways and regional futures. In this review, mineral resources were discussed with focus on subsoil asset such as oil and gas and solid minerals in mineral-rich regions. The drivers of resource extraction, such as globalisation and sustainability as well as benefits and consequences were examined. The economic, environmental, and social impacts of extractive activities was highlighted with examples drawn from different regions of the world. In many of the regions, poor management of natural resources results in poor outcomes in many of the assessment criteria. To address these limitations, resource and environmental governance regimes have been applied, however, knowledge gap and uncertainty and natural resource and environmental complexities obscures efforts toward management.

2.1.1 Characteristics of Resource Extracting Regions

Geological resources (subsoil assets) play important role in underpinning the future prosperity of our society (UNECA, 2002). It is an important composition of the wealth of many nations and plays a key role in their development. These resources of intrinsic economic interest in many regions where they are located have undergone decades of extraction with historical production, proven reserves, and on-going extractive activities. They are both economically and politically important as they influence geo-strategic politics; for example, extraction of solid minerals, oil and natural gas (Khoday

& Perch, 2012). Extraction inherently leaves environmental and socio-economic footprints such as ecosystems disruption, economic inequality.

Vast amounts of research from different theoretical underpinnings have been conducted to understand the mineral resource wealth–economy–environment interaction for countries with subsoil resources. In many of these countries and regions, an approach/mechanism to sustainably manage extractive activities and the wealth it generates has been elusive, and the consequences of mineral extraction persist. For example, to understand the wealth per capita derived from the extractable subsoil assets, calculation is made with reference to the sum of subsoil assets (oil, natural gas, coal, and minerals) according to the World Bank total wealth estimates.

Many countries and regions with subsoil assets that have witnessed decades of extractive activities have retrogressed as explained by the resource curse paradigm or degraded through destruction of ecological resources and ecosystem services in pursuit of mineral exploitation (Auty, 2007). Conventional scholarship suggests that the sustainability of these regions is premised on available reserves of extractable stocks and the ability to translate the stocks of natural capital to other forms of capital that benefits the society (Hartwick, 1977; Lange & Wright, 2004). Because this study aims to explore the construct of sustainability of mineral extracting regions from a broader perspective of management including ecology, equity, and futurity as a robust approach to understand natural resource wealth instead of the macroeconomic construct and plane reduction of nature's resources to monetary and gross domestic product (GDP) values. We explore subsoil asset data to see how it can advance our understanding of the research concept. Figure 2.1 presents subsoil assets in dollar (sum of oil, natural gas, coal, and minerals) per capita of countries from 2005 data as estimated by World Bank staff. It is an attempt to understand the relationship between mineral/energy resources and population. It could be useful in determining the sustainability of countries who depend on mineral wealth for economic growth based on available extractible stocks.

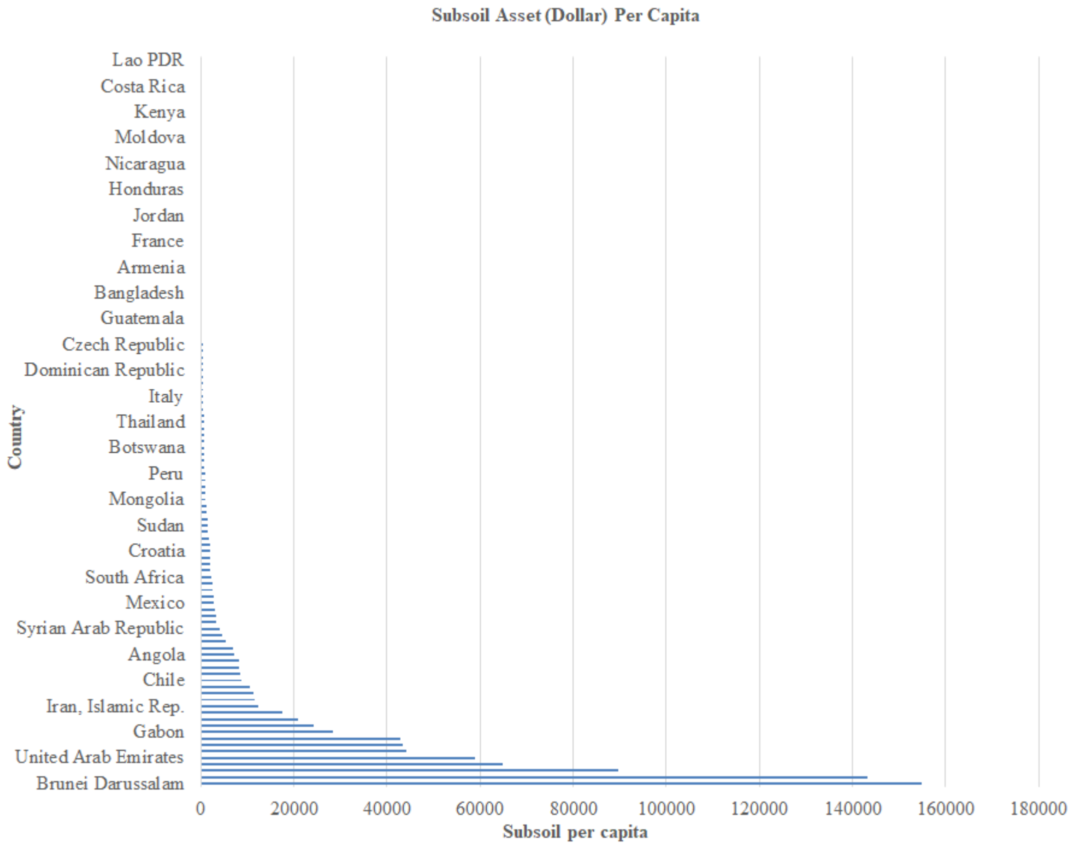

Figure 2-1 Graph of Countries and Subsoil Asset. Data Extracted From Total Wealth Estimates and Per Capita Wealth Estimates. Wealth of Nations Database World Bank (2005)

In the attempt to understand the importance of mineral resources as assets that can change the economic dynamics of nations with mineral wealth; Hailu & Kipgen (2017) conducted a study that aimed towards understanding the degree of dependence on non-renewable resources and the sustainability of growth in resource-rich countries. They introduced a new index (Extractives Dependence Index) for measuring an economy's dependence on natural resources with focus on oil, gas, and solid minerals and allows for ranking among countries. Through a statistical approach, index values were calculated for a total of 81 countries between the year 2000 and 2011. This approach assigned different scores to countries whose economy depends on mineral resources export including Nigeria which has an EDI score of 81.05 signalling its huge dependence on natural resource for economic sustenance. The effect is that alternative sources of export and tax revenues including diversification through manufacturing and other industrial capacity reduces the dependence on the mineral and energy sector and consequently leads to a reduction in the EDI value. The EDI analysis is more methodical compared to the subsoil asset per capita estimation although both approaches aim to interpret the linkage between the resource-economy-social interaction so as to understand the benefits of minerals, their utilisation and sustainability. A robust understanding of the interaction would ensure the resilience of an extracting region and communities and ensure the sustainability of a region does not come at the expense of another. Figure 2.2 presents the EDI for a group of extractive resource dependent countries.

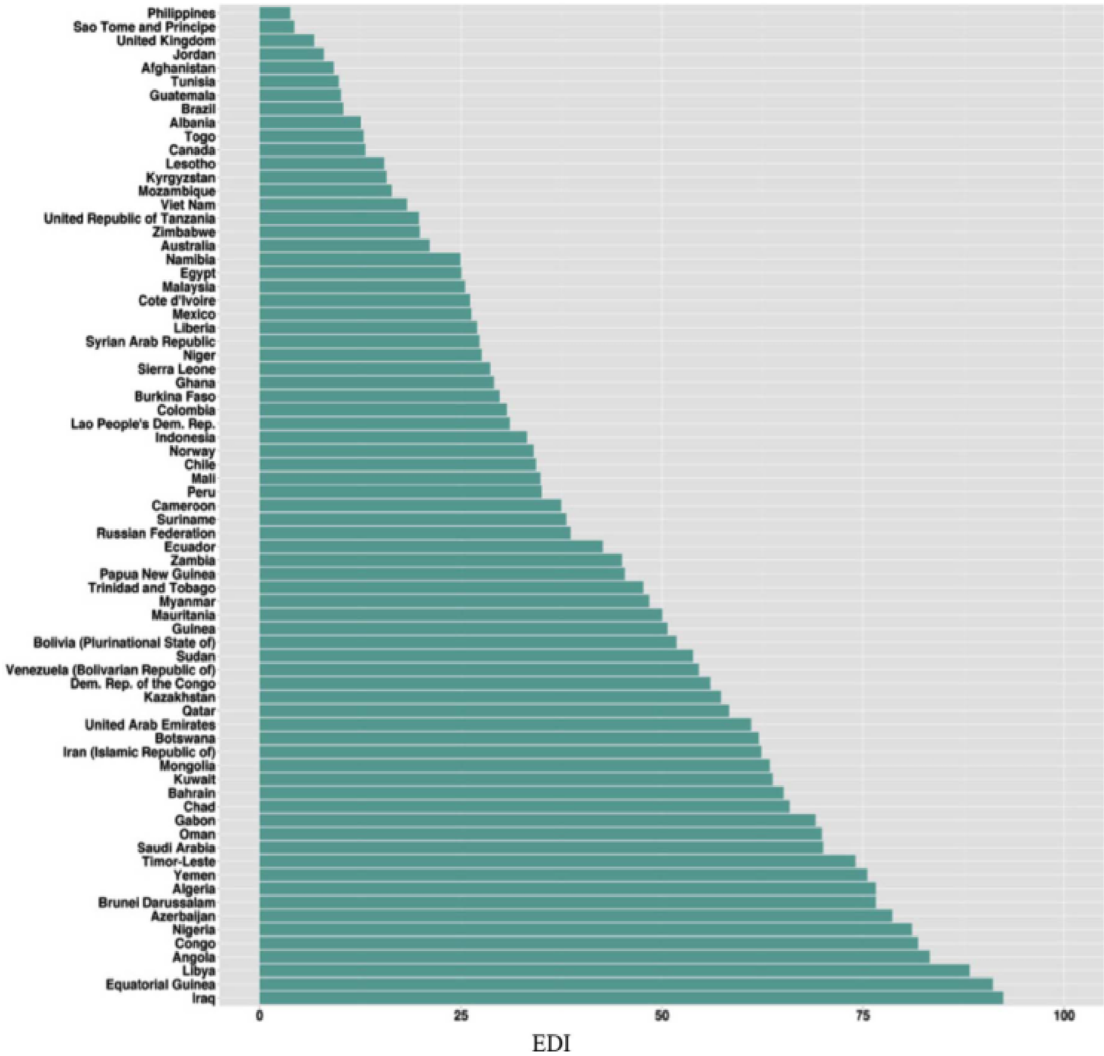

Figure 2-2 EDI Results for Countries in 2011. Source: (Hailu & Kipgen, 2017)

In addition to such impacts, other problems confronting these regions include environmental pressures such as deforestation, habitat fragmentation, soil erosion, landscape changes, seismic perturbations and subsidence, all of which are either directly or indirectly linked with exploration and extractive activities. These environmental pressures are complex; they emerge from intricate human activities that are shaped by biophysical processes (Herbert et al., 2013). Mineral and energy resource extraction remains a great threat to some of the world's most pristine areas and has continued to threaten both national and internationally conserved areas including wetlands and unique ecoregions; examples are the oil-rich Amazon reserve and the oil rich Yasuni National Park of Ecuador which is an area of staggering biological diversity and natural resource asset. In the artic, oil exploration in Norwegian oil fields threatens the Barents Sea and mining wastes threaten Norway's fjords. In the Niger Delta Nigeria, decades of hydrocarbon exploration and extraction has massively impacted the region's ecosystem. The region continuous to receive high levels of greenhouse gas emission whose consequences are both local and global.

Fossil fuel will continue to dominate energy sources for the next several decades (World Energy Council, 2016; Zou et al., 2016) with the United States fossil fuel production and consumption due to rise in the next couple of years (EIA 2018). The world will continue to rely on oil, gas and other fossil energy to meet its energy needs until the production and utilization of renewable and green energy meets the global energy demand. Although investment in and yields of renewable energy resources have increased tremendously in the fight to reduce anthropogenic impacts arising from fossil energy consumption, lack of availability of rare earth metals and low energy-return on investment (Höök & Tang, 2013) as well as unpredictability in weather conditions could constrain progress in the green energy industry. Fossil fuel consumption accounts for over 78% of global energy use with oil being the world's number one strategic commodity. The demand for energy and the evidence that oil and gas will be used to meet much of this demand over the next several decades is important to our environmental and energy futures since the world economy is currently supported by fossil fuel consumption. This continues to represent a conflict of interest among multiple players pitting the energy industry, governments, environmentalists, and communities against each other. Oil is a strategic commodity and being aware of the contribution of fossil energy to global climate change and the impact of extractive activities on the environment and rights of indigenous people who depend on local ecosystems requires a better understanding of their interactions to ensure the sustainability of the environment and communities in resource regions. For example, globally, petroleum accounts for 37% of primary energy consumption and more than 90% of transportation fuel (gasoline, diesel fuel, and jet fuel), but only 1% of electricity generation (Smith et al., 2013; EIA 2018). Figure 2.3 presents a chart of total world energy consumption in relation to energy type. This shows that the world energy system is currently heavily dependent on fossil energy and therefore extractive and associated activities in resource rich regions will continue until the world transitions to the renewable energy system which is more sustainable. Figure 2.4 shows that fossil fuel production forecast in the US would rise to reach record levels in 2018 and 2019 according to the U.S. Energy Information Administration (EIA 2018).

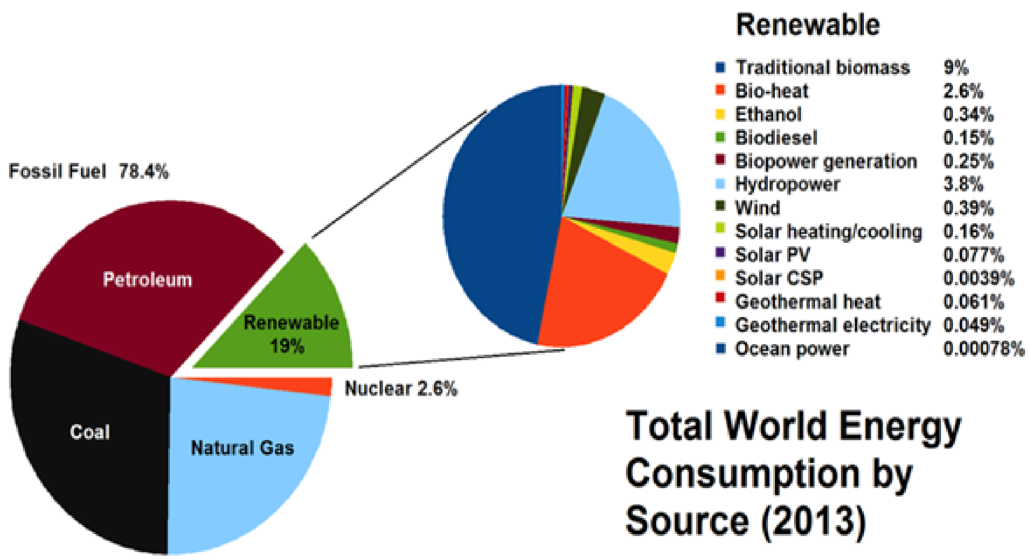

Figure 2-3 Total World Energy Consumption. Source: Ren21 Renewables 2014 Global Status Report.

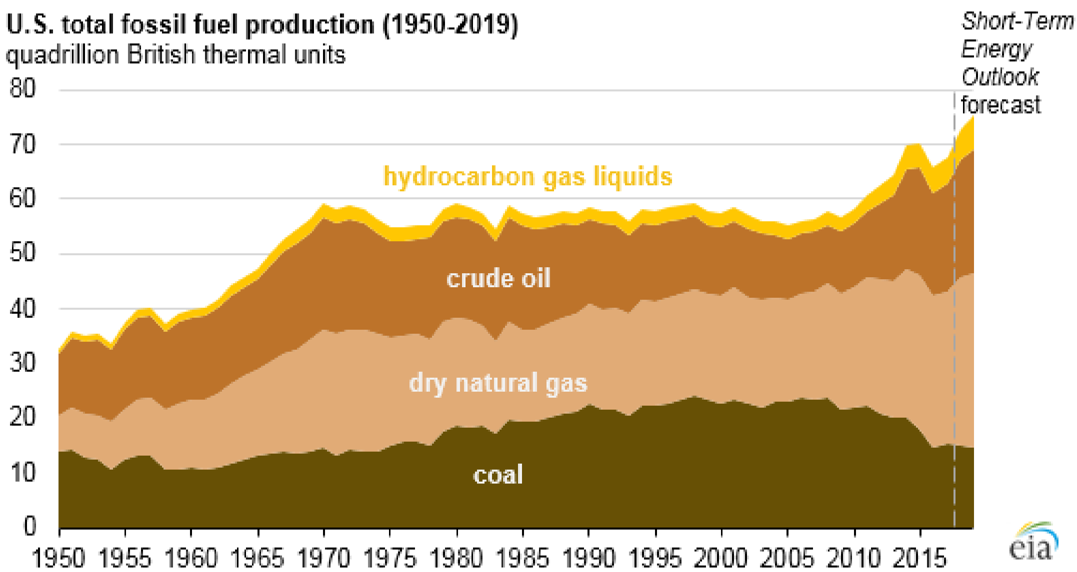

Figure 2-4 U.S. Fossil Fuel Production Forecast to reach record levels in 2018 and 2019. Source: EIA 2018

2.1.2 Drivers of Resource Extraction

In an increasingly connected global society, this generation has seen the forces of globalisation in different ways and sectors: such as trade liberalization, communication, and information storage, technological innovation. Globalisation and sustainability are two key drivers of mineral and energy resources extraction which aims to provide global resources needs whilst simultaneously using derived benefits to build capital that can be transmitted to the future generation. The consequences of mineral extraction challenges conventional coordinates of space and time because the world is more connected, and impacts transcend communities, regions, and national borders. These twin key drivers (globalisation and sustainability) have caused the emergence of a new paradigms in which non-traditional institutions now have a stake in the extractive sector: institutions such as environmental organisations, financial institutions and private actions that challenge the traditional state-centred approaches, despite their important historical legacy (Herbert et al., 2013). It has also resulted in the creation of new global governance regimes and institutions to manage trans-global economic and environmental interactions. Several scholarships have demonstrated that environmental harms generated from energy and mineral production benefit some and harm others in disproportionate measure (Bridge, 2004; Bunker, 1985). The harms are extensive, and it is a challenge to comprehend some of its underlying dynamics because they involve multiple scale, layers and actors and are confoundingly complex. However, problems associated with resource extraction cannot be attributed to the latent subsoil assets but the configuration of interest and interactions that have developed around its exploitation and the quality of institutions in charge of management. Studies have been conducted to relate and understand the consequences of anthropogenic interventions in the environment and how these feedbacks interact with socio-environmental subsystems. Amongst the approaches that have been developed and deployed includes the Pressure-State-Response framework (PSR-F). Figure 2.5 is a Pressure-State-Response framework that demonstrates human pressure on the environment, the response and feedback system.

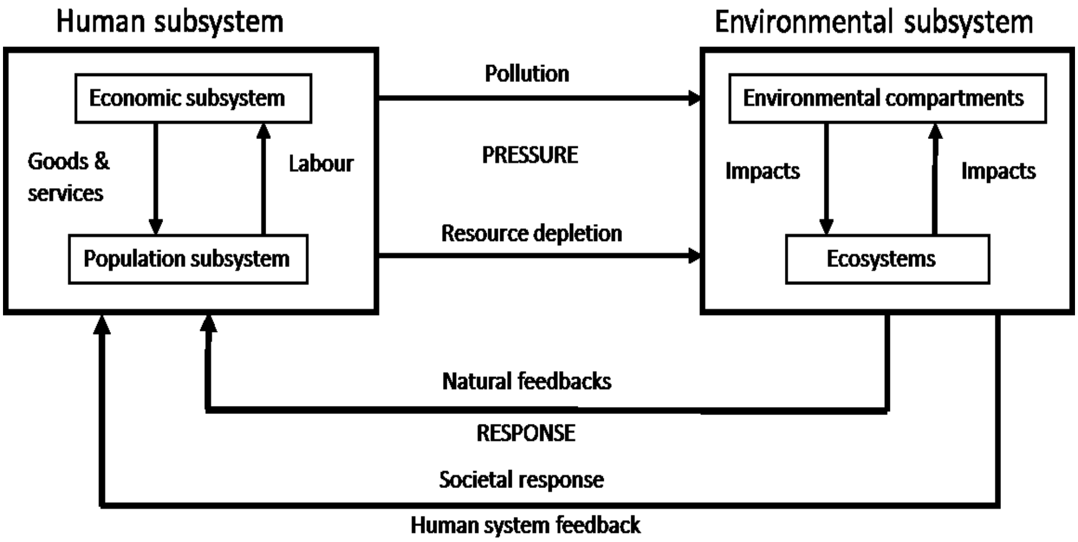

Figure 2-5 Pressure-State-Response Framework for the Indicators. Source: (Hammond et al., 1995).

Resource extraction and associated impacts have been a challenge for communities, investors, and policy makers. Therefore, a daunting task lies ahead for scientists, engineers, and policy makers to steer society towards environmentally sustainable management in this era of environmental degradation and resource decline caused by mineral and energy resource extraction. Natural resources (renewable and non-renewable; biotic and abiotic) and the environment exist in a complex socio-ecological structure (Ostrom 2009), with interaction between nature, technology and people.

For example, the Coatzacoalcos region and Tonalá Rivers Low Basin of Mexico hosts a huge infrastructure of the oil industry with unique ecology and rich biodiversity. This inherently makes the region vulnerable to the oil complex particularly with respect to oil/chemical spills and the associated socio-economic distortion in the region due to the industrial and natural ecosystems interaction (Mendoza-Cantú et al., 2011). The study demonstrated that the increasing level of vulnerability is due to extractive activities which span the biophysical (slope, relief, and permeability), biological (richness, singularity, and integrity) and socio-economic (economic activities index and social marginalization index) conditions. The study was aimed at producing a strategic plan for the management of the Coatzacoalcos geosystem. The Angola's Cabinda and Soyo regions host major subsoil assets as well as ecological resources. Management of these resources has been characterised by poor fiscal regime, exclusion, distributive inequity, and inequality. Ecosystem resource-dependent communities in the spatial proximity to extractive activities have struggled to maintain their livelihood; for example, subsistence farming and artisanal fishing, because of oil induced environmental degradation (Reed, 2009). Oil extraction has degraded the environment and the social organisation of the region and these are the major issues of conflict (repression, civil war, and secession). The Niger Delta Nigeria (ND) is another example of a mineral extracting region where hydrocarbon extraction has caused significant environmental and socio-economic problem coupled with human and infrastructural developmental challenges. The mangrove of the ND is a complex and sensitive ecosystem whose ecosystem services are essential to the fishing industry and the economy of the region and its preservation is crucial for the viability of a large coastal and wetland fishery (World Bank, 1995a). Table 2.1 presents some general criteria to understand environmental vulnerability variables in regions of oil extraction. It is worth noting that the natural environment changes by itself, however, most of the changes observed in the environment today are anthropogenically driven. Therefore, to manage the environment would mean managing people's interactions especially towards exploitation of natural resources because of the associated trade-offs.

Table 2.1 Variable and Criterion Interpretation for Assessing the Physical, Biological, and Socio-Economic Condition of Oil and Gas Resource Region.

Condition	Variable	Criterion
Physical	Land slope and relief	The steeper the slope and the more irregular the relief, the wider will be the crude oil dispersion and the more difficult will be the clean-up operation.
	Permeability	The higher the soil permeability, the deeper will be the oil penetration, the greater its persistency and the more difficult its cleaning and remediation.
Biological	Richness	A high number of species reflects a history of low ecological disturbance; these areas are considered more vulnerable and should receive special protection and conservation.
	Singularity	When an ecosystem is rare or scarce at a local, regional or global level, and when it includes endemic or protected species, it warrants protection.

Condition	Variable	Criterion
	Integrity	The fewer the patches of ecological disturbance within an ecosystem, the more conserved it is; and hence the more vulnerable
Socio-economic	Social marginalisation index	When the local people are highly marginalised, their susceptibility to crude oil spill damage is also high; these areas are considered more vulnerable.
	Economic activities index	Closer the dependence on the soil on the part of agriculture and industry, the greater will be the impact of a crude oil spill on the population income; and hence the greater the vulnerability of the area.

Source: (Mendoza-Cantú et al., 2011)

Figure 2.6 presents a schematic of human activity with the environment and the economy. The implication is that in pursuance of economic development, the environment is exploited which causes environmental resource depletion and degradation.

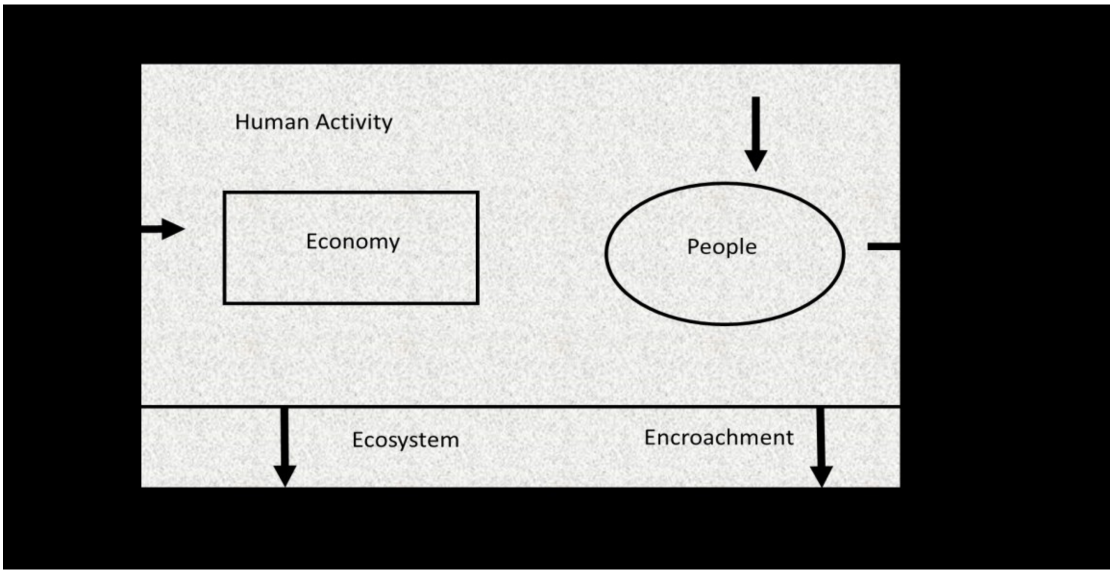

Figure 2-6 A Model of human interactions with the environment
Source: (Hammond et al., 1995)

2.2 Ecosystems Goods and Services

Human society and economy are dependent upon the natural environment for flow of natural resources from the ecosphere to the economy in the phenomenon referred as ecosystems services. Ecosystems services (ES), so-called, are the many services that nature provides to support life. This was extensively explored by the (MEA 2005). Many definitions and competing meanings have evolved from numerous pieces of research conducted in this field. The biological, chemical, and physical components of the ecosystem interact to deliver the final ecosystem service. Boyd & Banzhaf (2007), in making a distinction between services and benefits derivable from the ecosystem, defines final ecosystem services as "components of nature, directly enjoyed, consumed, or used to yield human well-being". Fisher and colleagues (2009) building on the above definition of ecosystem service propose a definition as "the aspects of ecosystems utilized (actively or passively) to produce human well-being". A robust and reflective definition of ES influences the way it is accounted for especially with regards to green GDP. ES are the values derived from nature that benefits and contributes to the well-being of households, communities, and economies (Boyd & Banzhaf, 2007). It is broadly categorized as provisioning, regulating, supporting and cultural services. Aside from these broad categories, some researchers view social capital in relation to ecosystem service based on the connection between social capital, human well-being, and environmental sustainability (Costanza, 2000). Some progress has been made regarding understanding our ecosystem and establishing practical measures to avoid degradation and exhaustion of the services they provide. However, much of the focus has remained in the realm of philosophy rather than being translated into action. This is demonstrated in the failures of markets and systems of economic accounting to adequately capture ecosystems services value as well as the reductionist use of the GDP as a measure of wealth, and the non-existence of market for non-merchantable ecosystem services (Boyd, 2007; Ochuodho & Alavalapati, 2016).These failures and the apparent limited understanding of natural systems could result in uncertainty and complexity.

2.3 Resource Security, Global Benefits and Local Cost

Economic globalisation of businesses and the need to provide energy and stock materials for industrialised economies, which is critical to national security, and geostrategic interest would continue to drive mineral and energy resource exploration and exploitation. For many nations, the need to acquire critical resources and energy materials to ensure energy security has resulted in conflicts and resource wars. This results in instability and threatens access to critical resources. When put in historical and geographical context, the dynamics are changing, considering that environmental degradation, economic inequalities as well as socio-cultural issues in regions of mineral and energy resource extraction is currently one of the most potent threat for maintenance of access to resources due to the globalisation of environmental and socio-economic problems. These emerging paradigms have been bolstered by events such as global warming, biodiversity loss, public health, inequality, and others. The export of critical commodities generates revenue for governments in regions of extraction whilst globalisation and the increasing sophisticated supply chain systems has eased the historic bottlenecks associated with mineral resource exchanges and transaction resulting in mineral exploitation in remote regions with limited constraints to getting commodities into the global markets. However, considering that the process is subject to external influence, it has led to the depletion of natural resource, waste generation and higher ecological footprints in these regions of extraction with unprecedented impacts on both man and nature and represents an epoch in the history of economic, social, and ecological relations.

2.3.1 The Resource Curse Paradigm

It has been demonstrated through studies that nations that are primarily dependent on non-renewable natural resources tend to grow more slowly than countries that are resource poor. They often suffer from weak institutions and poor governance (Isham et al., 2005). Studies have shown that in regions/states with deposits of mineral wealth, there is capture of resource wealth by the elite. The resource curse theory describes a phenomenon in which resource export boom prompts a rise in earnings which leads to increased spending consequently causing the real exchange rate to appreciate so that the non-traded sector becomes uncompetitive and consequently crowds out non-oil exports and ultimately slows down economic growth (Auty, 1995; Humphreys, Sachs, & Stiglitz, 2007; Sachs & Warner, 1995). Although mineral resource offers a promise of economic hope to countries where they are deposited and discovered, the real challenge lies in transforming these underground resources to above the ground-built capital as well as liquid assets that benefits the society and future generations through optimal and responsible resource policy and governance.

Figure 2.7 is an analytical framework of the transmission channels of resource wealth and the impact on local outcomes. The framework underscores the significance of institutions (political, regulatory, fiscal decentralization) in bringing benefits and development that should benefit the society, including future generations or result in the so-called resource curse paradigm.

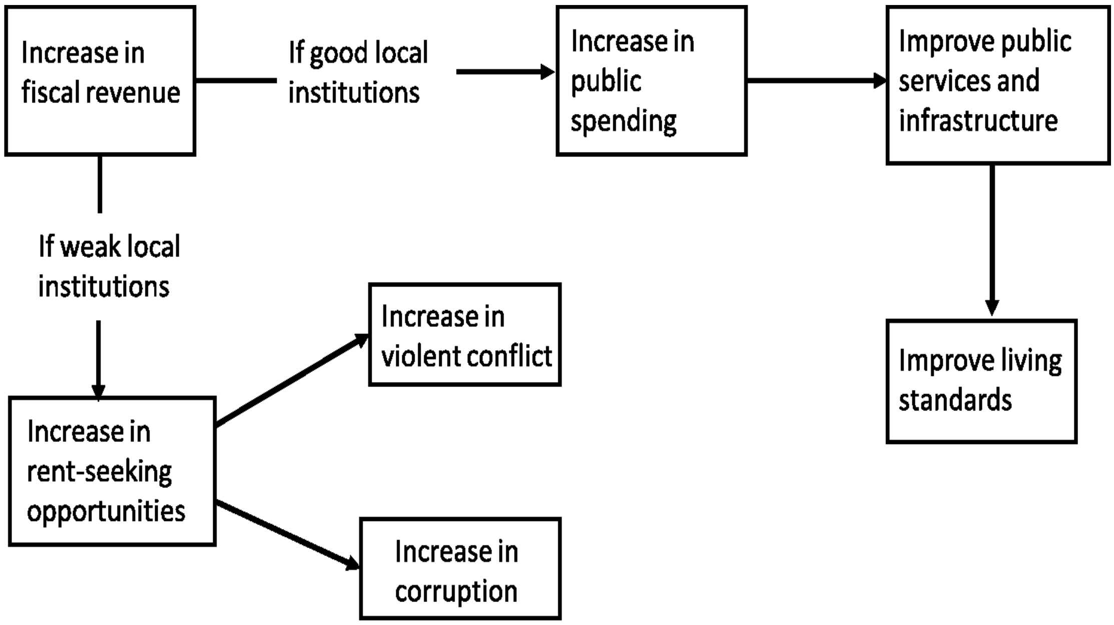

Figure 2-7 Fiscal Revenue Windfall: Source (Punam et al., 2015)

2.4 Natural Resources Accounting: Limitations and Implications in Regions of Mineral Wealth

It has been shown that economic development of mineral resources through resource exploitation has led to degradation of the environment. This has increased over the past decades with some of the most pristine areas deteriorating with heavy environmental fingerprints. Large scale anthropogenic impact on the global environment has increased in intensity and should be mitigated through rational resource and environmental policy formulations. Poor policy instruments evidenced in poor resource accounting systems, market failures; in which gains, and externalities associated with resource extraction are disproportionally allocated presents a problem for many stakeholders in many regions of mineral wealth. For example, Ecological Economists posit that whilst some ecological resources are priceable, limitations remains for resources with no existing market (Boyd, 2007). Despite efforts to create proxy or hypothetical market and valuation methods, there have been shortcomings due to trade-offs and knock-on effects on unquantifiable, non-transactable and non-merchantable ecosystem resources arising from economic exploitation of geodiversity (mineral and energy resources). The equation of nature's services to plain monetary terms (most times undervaluing them) incentivises trade-off scenarios on adjacent ecosystems. Paradoxically, the pursuance of market and economic expansion which is construed as development, whilst subordinating socio-cultural values and ecological principles, is misleading (Rajeswar, 2002). The ecological subsystems of mineral producing regions provide services that cannot be traded off without a collapse of the ecosystem in the long term (e.g. Carbon sequestration, photosynthesis etc.). Carbon sequestration which is the process in which carbon dioxide (CO_2) a leading cause of climate change is stored in soil as part of the soil organic matter. Similarly, trees sequester carbon dioxide (CO_2) into sugar, cellulose, and other carbon-containing carbohydrates that they use for food and growth in a process of photosynthesis (Sedjo & Sohngen, 2012).

2.5 Environmental Accounting

Environmental accounting is a suitable metric for representing interactions between the environment and market activity because it aims to capture variables the conventional accounting system omit (Nordhaus & Kokkelenberg, 1999). Ochuodho & Alavalapati (2016) states that conventional accounting variables such as the Gross Domestic Product (GDP) is trailed with limitations and shortcomings because it fails to fully account for depletion of resource stocks, environmental degradation, and ecosystem services losses. Also, additions made when new resources are discovered and revaluations due to changes in price highlight the need for a comprehensive and adaptive accounting framework. For example, when eco-regions such as the freshwater swamp forests and mangroves, which is one of the world's most productive ecosystems, are cleared to extract energy resources (oil and gas), this increases GDP without considering the loss of these natural resources and environmental assets including the economic value of the degradation of water, air or recreational value of these assets and other ecosystem services that have been altered. Assessment should be based on the environmental sustainability of economic activity in relation to the cost of consumption of natural capital (natural resource depletion and environmental degradation).

For example, in a resource-rich and dependent country like Nigeria, the concept of national wealth is based on GDP. This accounting approach does not subtract from the income figures the depreciation value of the asset base generated through resource depletion (Coria & Sterner, 2011), neither does it factor in the massive and unprecedented destruction of biodiversity and ecosystem resources in the oil and gas producing region. This brings the sustainability debate to bear especially when natural capital is depleted without replacement with other forms of capital i.e. infrastructure (power, piped/portable water supply, roads, rail, telecoms, education, health care systems). Proper environmental accounting allows governments to produce robust economic and social policies including regulations on pollution, abatement costs and compensation for damages to ensure environmental and social sustainability. Figure 2.8 presents a schematic framework of how natural resource wealth can be mobilised to deliver sustainable development.

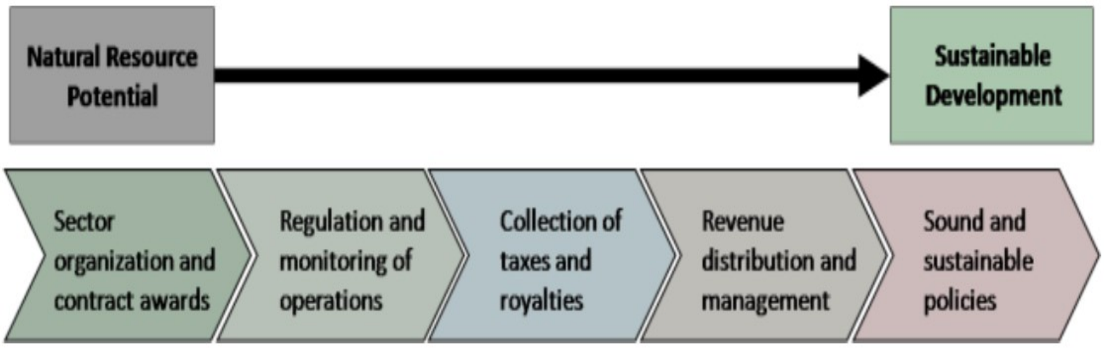

Figure 2-8 Natural Resource Mobilisation Framework. Source: Mayorga-Alba (2009) in Barma et al., 2012)

The framework demonstrates that natural resource can be mobilised to ensure sustainable development through a series of well-planned steps. For a large-scale natural resource extraction projects such as oil and gas, there are several contracts to be signed from governments and their national oil companies to multinational oil companies (MNOC), to banks and engineering companies and others. Governments should ensure contracts are transparent and negotiated to get a good deal and to maximize the revenue accruing to the government. This can be achieved through strengthening of the institutional capacity in charge of these undertakings. Strong institutions will ensure regulations and monitoring are carried out to ensure compliance of stipulated laws and guidelines. Collection of taxes and royalties should be transparent with biddings and payments published for public scrutiny. Government must ensure the equitable distribution of natural resource wealth and avoid the patronage network as seen in many mineral dependent economies through formulation of strategic policies to ensure inclusive development and avoid the negative effects such as the resource-curse effect.

It has been shown that mineral and energy resource extraction inherently generate negative externalities that can affect the state of the environment and leave irreversible impacts. These activities create increased entropies in social formations and economic system as well as destructive environmental effects through release of contaminating toxic emissions, gas flares and oil spills that degrade the ecological quality including soil and water status. The consequence is severe impact to human health and ecosystem effects such as negative effect on agricultural productivity through loss of output as well as decline in fishery resources. The absence of basic infrastructure such as water treatment facilities and piped water, operational medical facilities to cater to the health needs of communities and lack of clean energy sources has contributed in making health outcomes worse. Figure 2.9 demonstrates possible pathways through which the exploitation of natural resources has a negative systemic effect in regions of mineral extraction.

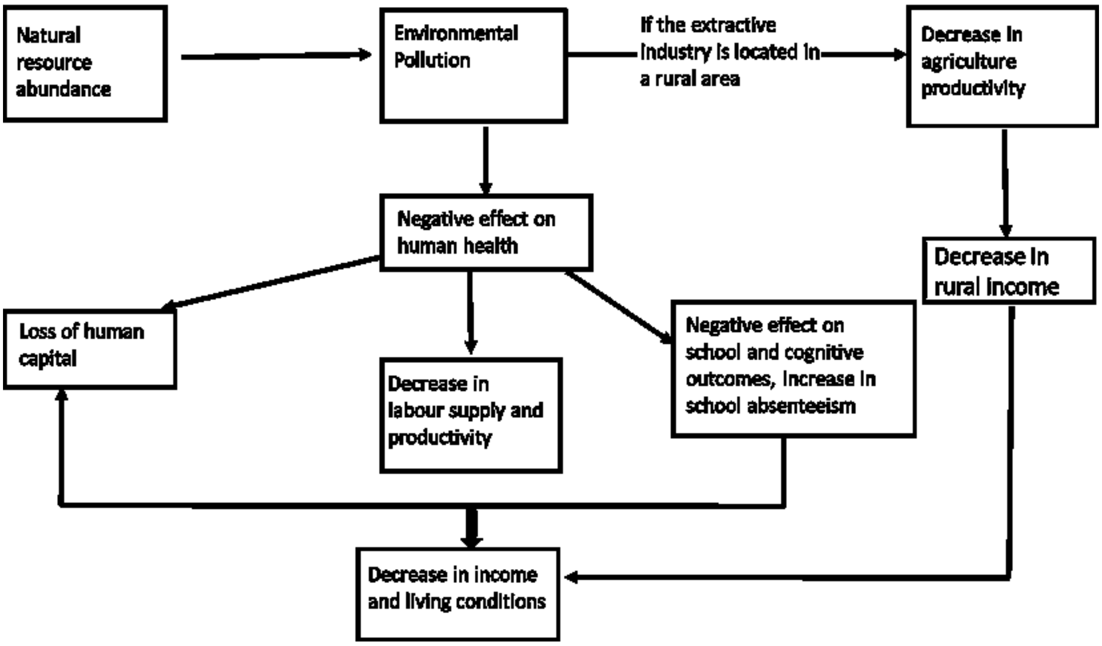

Figure 2-9 Environmental Pollution Framework From Mineral Extraction (Punam et al., 2015)

2.6 Environmental and Resource Governance

Governance regimes rely on economic (trade, subsidies, markets, taxes); socio-political (governance, institutional and legal framework) or mixed approaches to deliver environmental and natural resource interventions. This derives from different spatial jurisdictions (international treaties/accords, national legislation, regional and local decision-making structures). Governance can be shaped through self-regulatory mechanisms (Lemos & Agrawal 2006), or through institutional intervention. Nation states are viewed as the appropriate agents of action while international regimes oversee the global governance regime. This continues although shortcomings in governance regimes have characterised the international environmental regimes (Lemos & Agrawal, 2006) which is partly due to the *lex impefecta* of many of the regulatory instruments — which describes a law or statute that prohibits an action or behaviour with no legal sanction for violations. However, international governance regimes have succeeded in making progress through several ways including incorporation of scientific, technological, and lay knowledge in the information landscape; involvement of diverse and multiple actions and finding modalities of cooperation and developing cooperation and synergy to deal with common prevalent global problems. Examples are the Kyoto Protocol and Paris Climate agreement, Rio de Janeiro Earth Summit on

Convention on Biological Diversity, and others. Although different approaches can be employed to govern and manage natural resources, nation states hold the levers of power that can be applied to implement these agreements. While there are common features/characteristics among many mineral extracting regions of the world, the differences between them lie in the kinds of interaction surrounding their exploitation as well as the management and regulatory institutions.

2.7 Complexity

According to Pahl-Wostl (2007), complex systems are characterised by their non-linear behaviour, threshold effects, presence of many actors with different world views over a problem that is not clearly defined and therefore subject to different stakeholder interpretation. Environment and natural resource systems are inherently complex Stankey (1994) and studies have demonstrated that complex interactions and feedback exist between human and natural systems (Liu et al., 2007). Social-ecological interactions result in another layer of complexity which most of the times are not immediately observable because of the time-lag effect of such interaction. Ostrom (2009) expounded the resource use problem in relation to the social-ecological systems (SESs) construct and how the process could lead to improvements in or deterioration of natural resources. SESs are complex adaptive system composed of two subsystems; the human society and economy. Ostrom (2009) subsequently presented four core units of an SES that interact as well as their associated social, economic, and political settings. These include the: resource systems, resource units, governance systems and users. The author went further to produce a framework that can be used to diagnose natural resource systems interaction to ensure the sustainability of complex socio-ecological systems. The Framework is presented in Figure 2.10

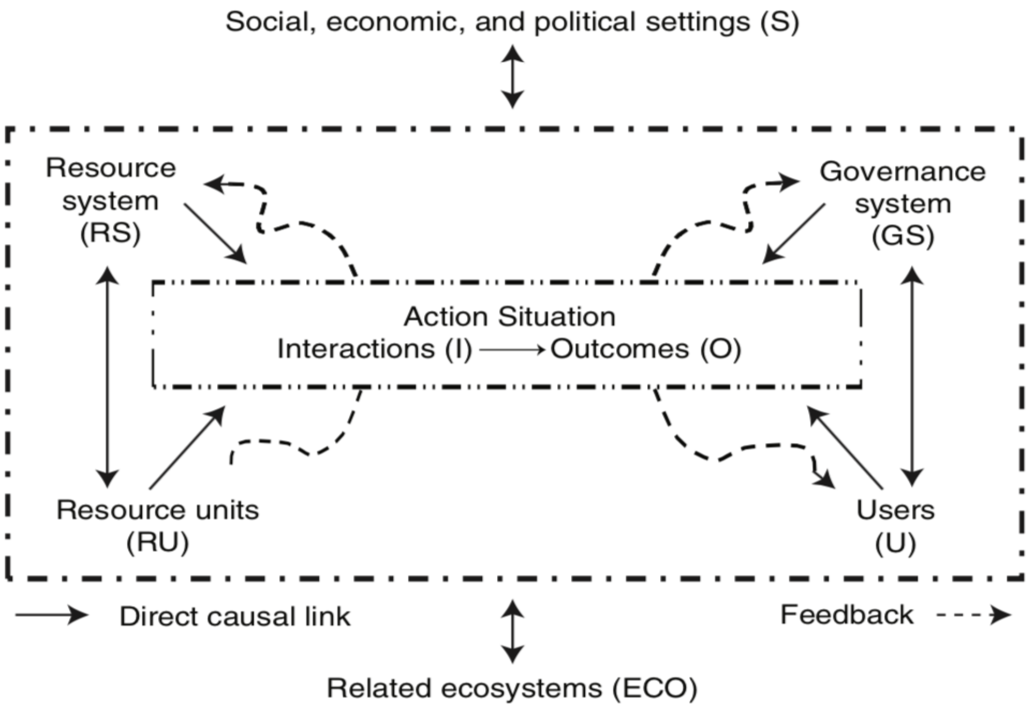

Figure 2-10 The Core Subsystems in a Framework for Analysing Social-Ecological Systems. Source: (Ostrom, 2007)

In a world beset with complex and unstructured environmental and resource problems such as environmental degradation, resource depletion, global warming and climate change, growth unsustainability, structural poverty driven by myriad of factors across multiple scales, problem solving needs to be holistic, interdisciplinary, and engineered by a systems mind-set. The resource-environment-economy interaction creates complex and sustainability problem that is modifying and shifting the paradigm of human interaction with nature. Niemeyer (2004) posits that complexity is a driver of change in deliberative processes and should be appreciated as it can result in a win-win situation if understood and exploited. Frank and co-workers (2013) state that environmental, economic and social impacts of extraction are inherently complex with multiple and generational effects on both spatial and temporal scales whilst (Axelrod and Cohen 1999) expressed need to harness and operationalise complexity instead of ignoring the inevitable; that is complexity should not be seen as a threat but an opportunity. Complexity and uncertainty characterise environmental policy-making because of multiple driving forces that unfold across spatial and temporal scales (Volkery & Ribeiro, 2009). Complexity is not connected to how much knowledge we have because it is an inherent characteristic of environmental and resource interactions and differs from uncertainty, which is based on knowledge gap. Examples of a natural complex systems include water catchments, airsheds and aquifers which are characterised by a dynamic behaviour and are difficult to understand (Franks et al., 2013). Similarly, mineral extracting regions present difficult environmental problems because of increased and changing multi-modal interactions from mineral extraction and the resulting pressure on ecological resources with spatial and temporal implications. Complexity is a constraint to environmental and natural resource management and obscures efforts towards sustainable development by defying the reductionist approach that does not take cognisance of systems delays, feedbacks, and whole systems interactions. It can be broadly categorised in three divisions: algorithmic, deterministic, and aggregate complexity (Manson, 2001). It is noteworthy that an inherent characteristic of complexity is its potential to generate surprises that could lead to policy resistance. Some of these surprises can be avoided if problem conceptualisation and solution design are posed in a holistic context, taking account of complexity (Awerbuch et al., 2009). Some methodologies have been deployed to manage complexity and these include; reduction, statistics, simulation, and qualitative analysis.

I. Reduction: The argument around reductionism is that for the whole to be understood, the smallest parts and connections should be sufficiently described. This approach has been successfully deployed where comprehensive knowledge of small parts especially is required. It enjoys scientific credibility because it allows for scientific and empirical testing. However, as tactically necessary as a reductionist approach is, its deployment in tackling complex eco-social problems gets us into trouble (Awerbuch et al., 2009). The pro-holistic proponents are of the view that it leads to over-simplification of complex behaviours because of its inherent inability to take into account other factors that affect the behaviour of a system, factors necessary to see the big picture.
II. Statistical Approach: This is critical in testing hypotheses, examining for possible causal relationships, and equally useful for drawing up spatial correlations among variables. However, the limitation lies in the theoretical assumptions of reaching the 'Whole' based on numbers framed around limited choice parameters. Similarly, to some extent, this approach is reductionist approach.
III. Simulation: This approach to tackling complex problems leverages the computing capacity of computers to provide solutions. Relevant parameters and

variables are measured and introduced into equations with outcomes that could be compared to observations or other alternative scenarios. Simulations serve as proxies to understanding complex problems, but the process is usually based on assumptions that are limited. The framing of modelling equations with assumptions that are either limited or are lacking in hard data will influence the extent to which it can resolve uncertainties around the science-policy debate and according to (Mollinga 2010; Awerbuch et al., 2009) decisions from analytical approaches are science driven and not user driven.

The principles of simulations underpin the theoretical and practical assumptions of the Systems Dynamics Model (SDM) that attempts at understanding and managing complexity while Soft Systems Methodologies (SSM) represent diverse perspectives to understanding and managing complexity. SSM explores problems by examining the conceptual systemic constructs (Lane & Oliva 1998). Soft and qualitative systems methodology place emphasis on the 'whole' as against exactness, allows for inclusion of variables that are not usually measured by constructing mental models that are broad in perspective and enables the grasp of systems behaviour from general systems properties. These include structure, networks, and interactions. They rely on limited assumptions to know how much can be lost without affecting our understanding of the complex problem. The downside is that the direction of change in this approach is however confounded by its lack of precision. To deal with complex problems, a mix of the approaches mentioned above could be applied. Ladyman et al. (2013) articulated some features of a complex system and how its characteristics could help in creating foundational knowledge of systems research. These features include nonlinearity, feedback, spontaneous order, robustness and lack of central control, emergence, hierarchical organisation, numerosity and others. Each factor considered in understanding and managing complexity should be regarded as complementary and not exhaustive, and this demonstrates that solutions to complex problems with associated uncertainties do not lie absolutely in computing power (Hjorth & Bagheri, 2006) but in understanding the soft, unquantifiable but observable variables that influence environmental decisions and need to be objectively incorporated (Laurenti, 2013). Table 2.2 presents some of the characteristic features of a complex system.

Table 2.2 A Tabular Presentation of the Features and Characteristics of a Complex System

Features	Characteristics
Environment	A complex system is bounded with internal interacting components which could be influenced by the external environment
Non-linearity	Many complex systems are non-linear although nonlinearity is not a caveat to creating complexity. This means that a relatively small change can result in a dramatic change implying that response could be non-equilibrium due to input-output disproportionality. Caused by multiple different interacting parts resulting in unevenness of impacts.
Uncertainty	Due to complex set of interaction and adaptations, it is nearly impossible to predict with absoluteness the future state of a complex system
Conflict of interest	Multiple and competing interests and diversity of relationship
Feedback	This is a key signalling feature of a complex dynamical system that is time dependent. Interaction with other systems components could produce positive or negative feedbacks
Spontaneous order	A complex system is expected to show a degree of spontaneous order which arises from the aggregate random interactions between elements
Emergence	A complex system has the capacity to evolve and produce a characteristic feature that is different from its constituent components; such is usually a product of the interacting components of the system and usually beyond prediction or even control
Robustness and lack of central control	Robustness and lack of central control are characteristic of a complex system. The coupled presence of these features in any systems under observation evidences complexity
Hierarchical organisation	Entities organise into different properties and levels of structure that interact and display periodic behaviour, order, and symmetry in their architectural complexity

Features	Characteristics
Numerosity	More than a handful of individual elements (systems components) need to interact to generate a complex system
Relationship	A complex system is defined by the relationship with constituent parts
Learning and memory	Through the persistence of internal structure, exchange of energy, matter and information, a system can remember.

2.8 Systems Thinking

Systems thinking provides an approach to deal with complex issues in which actors need to see the big picture to enable shared understanding and collaboration to ensure effective management. It is effective for managing recurring problems where past attempts to fix them have created more problems. It offers a new way of thinking holistically whilst focusing on the components of the system, their interaction and net effect on the system (Maani & Maharaj, 2004). Robust natural resource policy decisions are predicated on holistic understanding of the components in the systems and its interactions (Daniels & Walker, 2012). Participatory model building leads to a holistic understanding of complex problems by seeing the linkages and interactions in the system and how such understanding creates the potential for optimal policies and solution pathways. Systems thinking is an important cross-sectoral, interdisciplinary, and diagnostic tool to understand interactions by improving communication and providing information on the vulnerabilities and resilience of a system as to avoid policy resistance and system collapse. One of the key benefits of systems thinking is its ability to raise our thinking to become aware of the consequences and benefits of interactions to effectively deal with complexity and consequently create the result we want. Soft systems approaches enable unquantifiable variables that influence environmental decisions to be integrated (Laurenti, 2013). Since systems are conceived, the complexity of a system lies in the perspective of the beholder (Manson, 2001). According to (Voinov and Bousquet 2010), environmental thinking that incorporates socio-economic processes requires complex systems analysis, the type advanced by systems thinking.

2.9 Sustainable Development

From several studies conducted to explore and reach acceptable empirically informed understanding about the sustainability discourse, a key variable that is pivotal to the progress of the study is intertemporal choices. The sustainable development principle was given a unifying definition by the World Commission on Environment and Development 1987 (The Brundtland Commission) which furnished its report to the United Nations General Assembly. The Brundtland Commission defined sustainable development as: "development which meets the needs of the present without compromising the ability of the future generations to meet their own needs" (United Nations, 1987). Emphasis is placed on fairness and promotion of intergenerational equity. Although originally focused on environmental protection, it has been expanded to encompass economic and social development. Two theoretical underpinnings of sustainability have been advocated: strong and weak sustainability based on the substitutability or non-substitutability of natural resource (Moran & Kunz, 2014). Strong sustainability (Costanza & Daly, 1992), advocates the non-interchangeability of natural and manufactured capital and therefore natural capital must be sustained through generations; however, proponents of weak sustainability (Pearce & Atkinson, 1993), suggest that the provision of equal developmental opportunity for both present and future generations is the ultimate insurance for intergenerational equity and sustainability; that is, by offsetting a decline or liquidation in natural capital by a proportionate increase in man-made capital, sustainability can be achieved. Hartwick's Rule, lends credence to the sustainability debates stating that under strict conditions, elasticity of substitution between natural and produced capital must be greater than or equal to one; that is, output elasticity of produced capital in production should exceed that of natural capital whilst population growth must remain at zero when technological change is absent (Hartwick, 1977). For solid mineral resources, closing the loop has been promoted to ensure sustainability since they are irreplaceable natural capital, whereas for energy (oil and gas) resource development, the World Energy Council (WEC) supports the tripartite construct of economic, environmental, and social progress in pursuit of energy development. Disappointingly, in many places, oil exploitation has failed to engender a self-sustaining economic growth which questions its viability for use in achieving sustainable development as it leads to a bleak economy and collapse of social institutions consequently producing poor economic and political outcomes. Mineral resource wealth when judiciously used through conversion to human, social, financial, and manufactured capital, targets the sustainable development agenda in many areas either through poverty eradication or provision of education, reduction of inequalities and others. Currently, there are 17 sustainable development goals adopted by Member States of the United Nations Member in 2015 called the 2030 agenda for sustainable development. These include: "(1) End poverty in all its forms everywhere, (2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture, (3) Ensure healthy lives and promote well-being for all at all ages, (4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, (5) Achieve gender equality and empower all women and girls, (6) Ensure availability and sustainable management of water and sanitation for all, (7) Ensure access to affordable, reliable, sustainable and modern energy for all, (8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, (9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (10) Reduce inequality within and among countries, (11) Make cities and human settlements inclusive, safe, resilient and sustainable, (12) Ensure sustainable consumption and production patterns, (13) Take urgent action to combat climate change and its impacts, (14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development, (15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (17) Strengthen the means of implementation and revitalize the global partnership for sustainable development".

Policies must be instituted to ensure the maximum capture of benefits of mineral development and minimizing its environmental costs and ensure the long run conservation of wealth as means of ensuring the sustainability of mineral wealth (Holden, 2013; Humphreys et al., 2007).

2.10 The Dimensions of Sustainability

Sustainability is a complex systems concept involving many dimensions in different fields of knowledge. For example, the factors a mineral extracting company would consider in achieving sustainability would be different from that of an agro-industry, however, the core principles remain. This makes linear thinking unsuitable to address its broadness including the moral question concerning the on-going damage to the ecosphere (climate change, biodiversity destruction) in relation to intergenerational equity (Endress, 2014).This research will explore the economic, environmental, social, and institutional interactions and interdependencies of mineral extraction by considering the consequences of present actions, acknowledging the existence of knowledge gap and the engagement of relevant stakeholders to promote dialogue whilst focusing on the sustainable development agenda. Figure 2.11 shows the thematic parameters that are considered in sustainable development as established by the United Nations Commissions for Sustainable Development. Figure 2.12 presents the spheres of sustainability proposed by the University of Michigan Sustainability Assessment report.

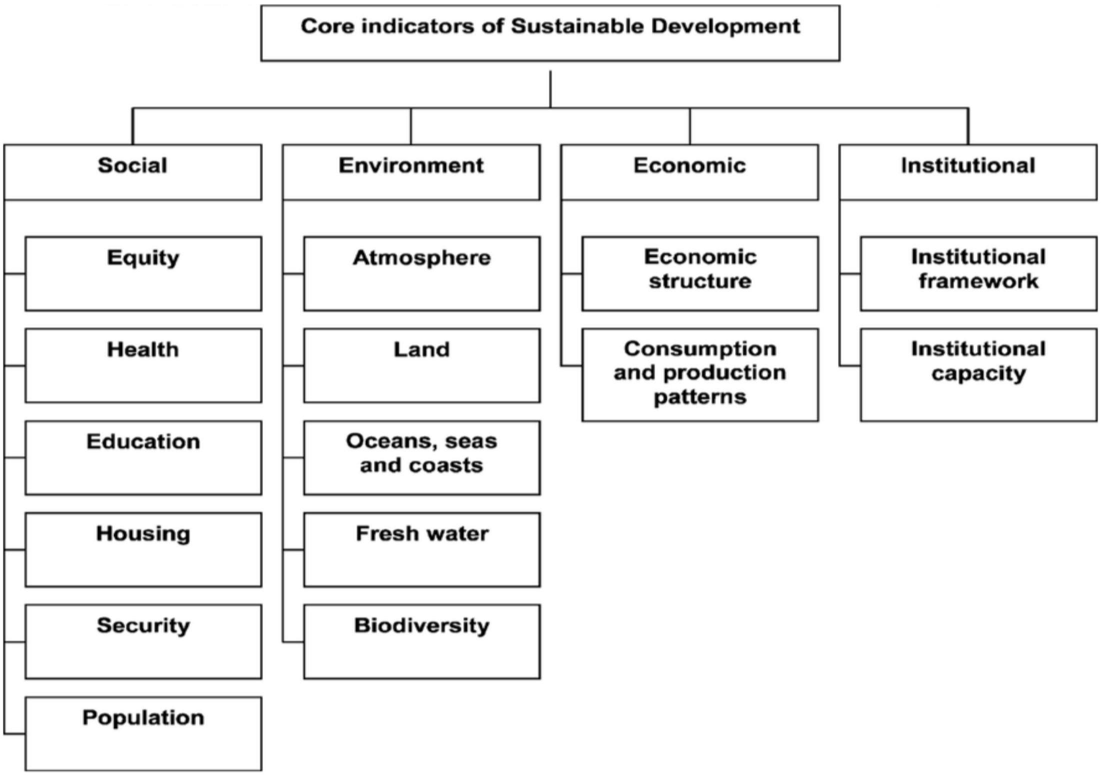

Figure 2-11 The United Nations Commissions for Sustainable Development (CSD) Theme Indicator Framework.

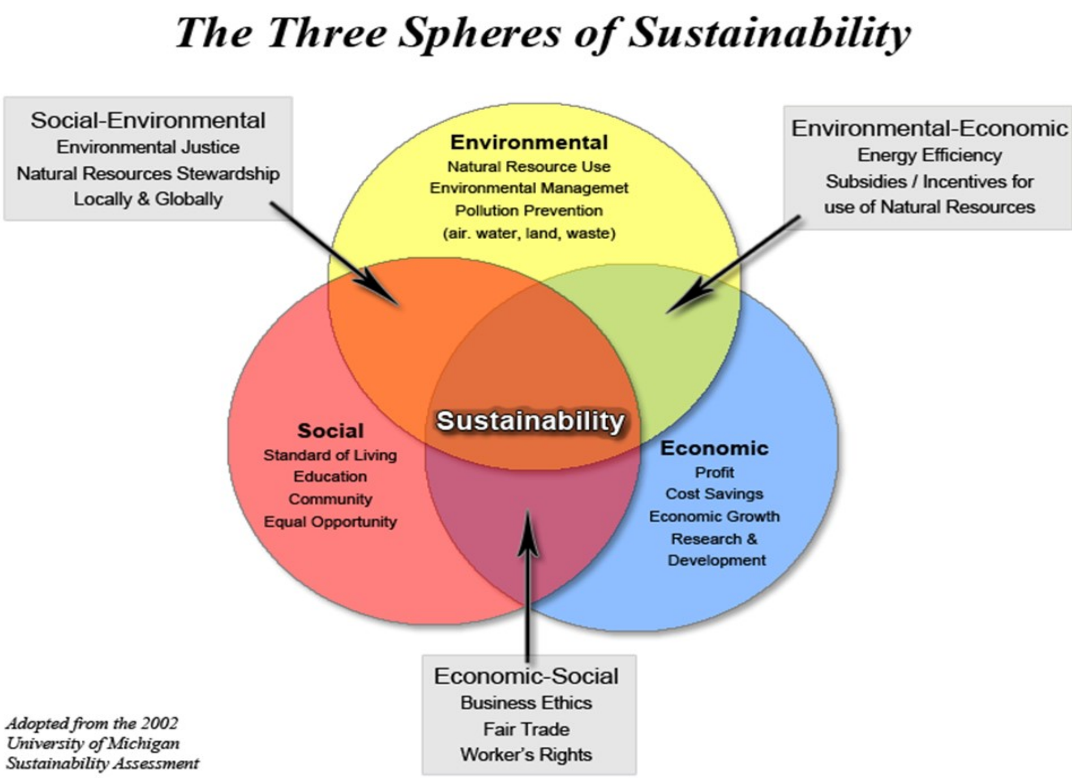

Figure 2-12 The Spheres of Sustainability Courtesy of The University Of Michigan Sustainability Assessment.

This thesis aims at the development of a tool/framework for the management of activities and regions of mineral resource extraction based on Systems Approach (SA). It develops its theoretical analysis on the proposition that resource extraction is complicated and represents a complex and unstructured problem that is cross-sectoral and inherently associated with environmental impacts and socio-economic consequences. Mineral resources management have been historically a complex activity, with mineral extraction paradoxically a double-edged activity advanced on the logic of economic development and environmental protection (Bridge, 2004). Diverse interests and multiple players; including international investors, national governments and local communities interact in a way that introduces a different layer of complexity in the system. This is usually challenging and creates a sustainability problem. Attempt to manage these problems through traditional approaches have been ineffective and incomprehensive and have not produced the intended outcomes. To address the complexity of these regions, system thinking has the potential to deliver benefits based on its holistic principles. Systems Thinking is critical in understanding complexity and therefore the proposed approach would be inclusive incorporating both quantitative data and qualitative information (participatory techniques) in developing a tool which application can deliver management objectives and ensure the sustainability communities and ecosystems of mineral extracting regions.

Chapter 3

3 AIM AND OBJECTIVES

3.1 Aim

The aim of this research was to develop a participatory systems framework to facilitate policy making and improve the management of mineral active regions.

3.1 Objectives

- Investigate the complexity of Mineral Resource Active Regions and evaluate the potential of re-assessing them from a systems perspective
- Review of systems decision-making approaches and methodologies for potential application to MAR challenges.
- Develop a systems framework to facilitate the management of MARs.
- Application of the MAR framework to a case study to clarify the boundaries of the research, establish systems complexity and identify stakeholders.
- Engage stakeholders in a participatory group model building workshop to generate information and build consensus on perspectives and actions that can result in the sustainability of MARs.

3.2 Structure of Thesis

This thesis consists of 8 chapters:

Chapter 1 introduces the thesis, the relevance of the chosen topic, and the proposed methodological approach.

Chapter 2 reviews the relevant background literature by exploring peer reviewed and non-peer reviewed literature as well as grey literature on mineral resource active regions. The characteristics of mineral active regions, drivers of resource extraction, implication of extraction on the ecosystem goods and services, the resource curse paradigm, natural resources accounting; limitations and implications in a mineral active region. Also examined is the resource governance concept, including activities that transform these regions to make them complex to manage. Complexity was found to be a major limitation to environmental and natural resource problems with severe implications on sustainability of these regions.

Chapter 3 presents the aim, and objectives of the research; the thesis' structure, and publications.

Chapter 4 offers review of existing studies on the adverse environmental and socio-economic impacts of resource extraction and proposes the need for systems thinking to managing mineral active regions. Conceptual models were developed as output of the chapter.

Chapter 5 The chapter explores the research design, methodology and strategy. Review of some decision-making tools and appraisal of the systems approach and its application as a research strategy. The systems approach was selected as appropriate tool that can be adapted in the management of mineral active regions based on its potential in managing complex problems.

Chapter 6 Based on the review of MARs along with environmental decision-making tools to support policy making: a framework was developed and subsequently applied in a case study (the Niger Delta).

Chapter 7 of the thesis focuses on the application of the framework to a case study—the Niger Delta as an example of a complex mineral active region. The framework is composed of eight steps. It starts with the establishment of the boundaries of the MAR. The history of the region was reviewed, features and characteristic of the Niger Delta catchment was highlighted. Secondary data on oil spill and gas flare in the region was explored to show behaviour over time graphs. The liability and compensation regime were discussed, and relevant stakeholders were identified. The participatory group model building (GMB) workshop and post modelling interviews were conducted. Reconnaissance visits, community consultations and site investigation were undertaken. Problem drivers in the region were identified. Primary oil spill data was obtained and analysed and graphically presented.

Chapter 8 of the thesis highlights the thesis discussion mapped against the research objectives, conclusion, and recommendations for future research was proposed.

The figure 3.1 is a conceptual framework of the thesis.

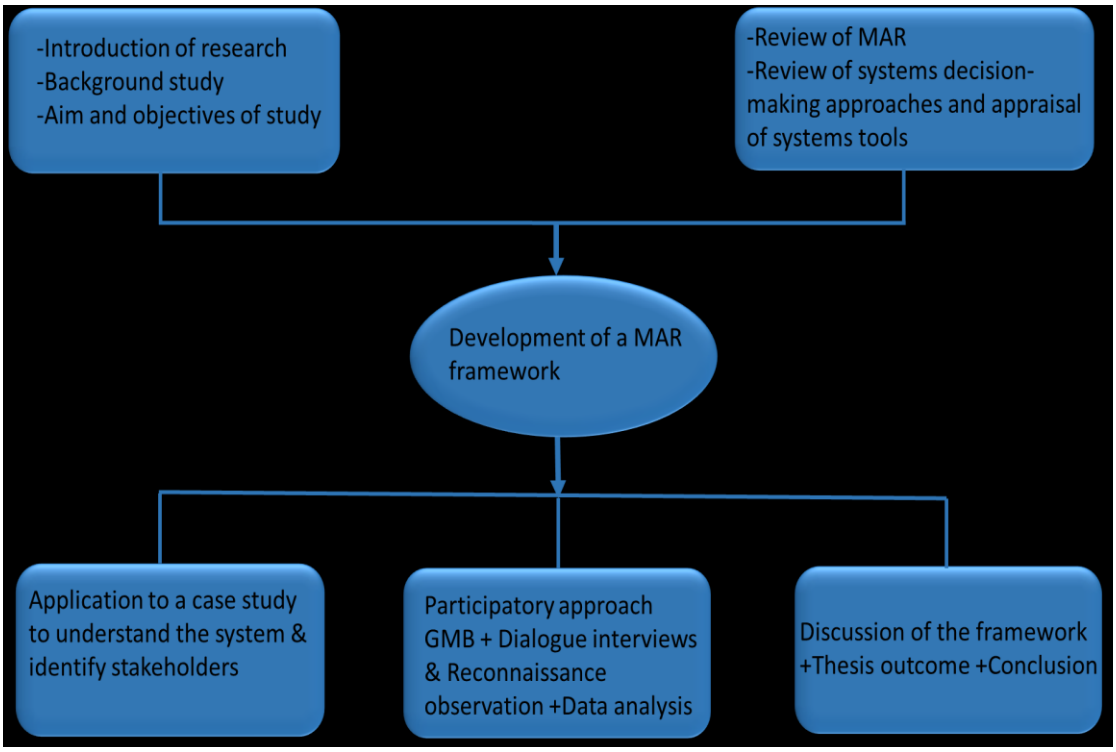

Figure 3-1 A conceptual framework of the Thesis

3.3 Publications

- Alozie, A. & Voulvoulis, N., 2018. Mineral resource active regions: The need for systems thinking in management. *AIMS Environmental Science,* 5(2): 78–95
- Alozie, A. & Voulvoulis, N., Appraisal of Systems-decision making approaches: Application of systems thinking to the sustainable management of mineral active region (In preparation)
- Alozie, A. & Voulvoulis, N., Development of a participatory framework to facilitate the management of MARs (In preparation)
- Alozie, A. & Voulvoulis, N., A participatory approach to systems thinking: Practical application of the participatory framework to a case study (In preparation)

Chapter 4

4 Mineral Resource Active Regions: The need for Systems Thinking in Management

4.1 Introduction

The natural environment is an emporium of resources; renewable and non-renewable (Asafu-Adjaye, 2005). Natural mineral resources are the lifeblood of modern civilization: the indisputable driver of the unprecedented development and prosperity the world has experienced over the past century (Bridge, 2004). Their extraction has fuelled economic development and will continue for a long time, provided that there are resources to extract while states have sovereign right over the exploitation of their natural resources[1] to meet economic needs. These resources are broadly described as natural capital based on all-inclusive construct (Roseland 2000; Costanza et al., 2006; Bryan et al., 2010); a term that captures all-natural resources known to be repositories of goods and services (geodiversity and biodiversity) and function to preserve and, stabilise the natural environmental conditions whilst provisioning resources and economic gains (Boyd & Banzhaf, 2007; De Groot, Wilson, & Boumans, 2002; Osuji, Erondu, & Ogali, 2010). Extracting companies profit on the exploitation of mineral resources which are viewed as physical materials from a capitalist perspective (Solomon, Katz, & Lovel, 2008). Historically, many countries with an endowment of energy resources and a plethora of mineral stocks struggled to maximize the benefits to the economy. Economic exploitation of minerals and energy resources has had environmental and social consequences and their development has not delivered sustainable wealth and prosperity to most regions where extraction takes place. However, studies have associated mineral wealth to corruption, democratic failures, conflicts and resource wars (Bhattacharyya & Hodler, 2010; Humphreys et al., 2007;

[1]Principle 2 of the 1992 Rio Declaration on Environment and Development

Ross, 2006) while Leite and Weidmann (1999) have associated natural resource rent-seeking to corruption, political instability and ultimately slowing down economic growth. These stocks of resources exist in varying spatial scales, localised and usually concentrated unevenly in different geographical areas (Ekins, 2000) and are heterogeneously distributed with some regions more mineral active than others because of geological, spatial and temporal configuration. The difference in geological distribution occasion demand and supply from regions of abundance to regions of lack and constitute the basis of international mineral and energy resource trade. These resources are spatially complex (O'Lear, 2012) and could be "point-source", "fugacious" and or "diffuse" and cannot be fully described based on geographical location since they are associated with human systems of demand and control, channels, and networks. However, point source resources such as oil and gas or solid minerals attract aggressive entrepreneurship (Mehlum, Moene, & Torvik, 2002), whilst various factors account for the economic viability of mineral deposits and these include; ore grade and type, mineral quality as well as engineering processes that are available to extract the resource (CEC, 2000; Franks et al., 2013).

Mineral Active Regions (MAR) are considered in this study as those with stocks of geological resources of intrinsic economic interest that can be used beyond the scope and or need of the local people and as a result, have undergone decades of extraction. These regions have commercially extractable deposits of minerals or energy resources with historical production, proven reserves, and on-going extractive activities. The value of the key functions of natural resources in relation to the value of resources exploited in pursuit of economic prosperity determines the degree of exploitation, degradation, and destruction of the ecosystem itself (Laurenti, 2013; MEA, 2005; Roseland, 2000).

Frank and co-workers (Franks et al., 2013) expounded the work of (Doloreux, Amara, & Landry, 2008; Young & Matthews, 2007) regarding "resource regions" by bringing definitional clarity. This study, therefore, complements previous research as it introduces the term Mineral Active Region (MAR) and further investigates traditional management approaches and why they have failed to address the issue of complexity and suggests the need for re-assessing these regions' problems from a systems perspective.

4.2 Resource Extraction Dilemma

Mineral extraction has caused unprecedented impacts at different scales with detrimental effects on both humans and nature (Bridge, 2004) and has been associated with a mixed legacy. Extraction activities come with significant environmental and human health effects (Moran & Kunz, 2014; Voulvoulis et al., 2013), socio-cultural impacts (Kitula, 2006; MMSD, 2002; Peck & Sinding, 2003), ecosystem and biodiversity disruption in areas where they take place (Azapagic, 2004; Kindzierski, 1999; Rourke & Connolly, 2003), in addition to contributing to climate change (Kuemmerle et al. 2014; Ite & Ibok 2013). Minerals, oil, and gas extracting regions experience similar socio-economic and environmental problems; however, context-specific environmental problems are known to exist. For example; air pollution, toxic waste emission, and acid rock drainage are noticeable in solid mineral extracting regions while oil spills, gas flaring, and venting, drill cuttings/waste are traced in regions of oil and gas extraction. Scalar mismatch and asymmetry in distribution of resource cost and benefits of which gains accrue to national governments, investors, and shareholders (in form of royalties, export earnings, taxes and rents) whilst the environmental and social costs are borne locally by communities endowed with mineral resource assets (Bridge, 2004; Esteves, 2008; Kohl & Farthing, 2012). Elite capture of resource wealth and deliberate case of negligence by statist and hegemonic systems is obvious in these regions coupled with asymmetries of power resulting in socio-political and economic exclusion with vestiges of colonial-era laws and policy instruments complicit in the disempowerment of indigenous people (Khoday & Perch, 2012) whilst in some regions inequality is obvious (Humphreys et al., 2007; Isham et al., 2005). Another dimension is the resource curse theory which has inspired a volume of theoretical and empirical research to understand the phenomenon where resource export boom (oil as a typical case) prompts a rise in earnings leading to increased spending (public and private) causing the real exchange rate to appreciate so the non-traded sector becomes uncompetitive and consequently crowding out non-oil exports and ultimately slows down economic growth (Auty, 1995; Humphreys et al., 2007; Sachs & Warner, 1995). This phenomenon is a recipe for economic shock because of the volatility of the boom and bust cycle akin to international mineral oil trade (Leite & Weidmann, 1999). Sachs and Warner (2001) have framed their argument of resource curse in relation to the crowding-out effect of entrepreneurial activity and innovation with a rise in earnings from the natural resource sector which could stifle or disincentivise economic growth; however, other researchers seem to agree with the resource curse phenomenon but view it through different discipline-based lens. Despite the variations in theories, the paradox is that natural resource wealth was originally construed as key to economic growth and development based on conventional economic reasoning.

Aesthetic distortion and landscape changes arising from extractive activities often overlap ecologically sensitive areas as observed in many MARs around the world. These regions bear the hallmark of lack of holistic accounting principles with consequent environmental and social modifications. Unsustainable depletion of resource stock arises due to failure to operationalise sustainability and view mineral wealth consumption as capital consumption rather than a consumption of profit. The effect of extractive processes aside being cumulative is characterised by high levels of technological, economic, geological and socio-cultural interaction with attendant uncertainties and ambiguities that create room for irretrievable environmental and social impacts (Canberra, 1995). Energy and solid mineral have been contentious as a point source and high-value commodities and their extraction is associated with significant loss of ecosystem services frequently at the expense of local people (Bebbington, 2013) who live in the periphery of the cash economy. Point-source resources have also been associated with bad policies due to undermined institutional capacity because it incentivises for central control of power (Bulte et al., 2005; Isham et al., 2005). Generation of waste, contamination of host environment, inequity in benefits and cost distribution, distortion of historical/cultural matrix and conflict plague these regions (Akpabio & Akpan, 2010; Bebbington, 2013; Jaskoski, 2014; Tiainen, Sairinen, & Novikov, 2014) while systematic underinvestment in education, health care and infrastructure (Cockx & Francken, 2016; Gylfason, 2000) is very obvious in most MAR of the developing world. These characteristic developments interact to engender growth unsustainability and resource decline with negative socio-economic and environmental fingerprints. Table 1 provides insight into the environmental and socio-economic impacts that characterise some of the mineral active regions of the world.

Table 4.1 Examples of mineral active regions and associated environmental, health and socio-economic impacts.

Region and Activity	Associated Problem	Reference
Mining in Pascua–Lama	Environmental degradation from	(Mendoza-Cantú et al.,

Region and Activity	Associated Problem	Reference
of Chile; Michilla and Chapaco.	tailings, effluents, dust, conflict.	2011; Urkidi, 2010; Vásquez et al., 1999)
Oil extraction in Cabinda and Soyo regions of Angola.	Environmental degradation from oil spill, inequity in cost and benefit distribution, conflict.	(LeBillon, 2001; Reed, 2009; Ross, 2006)
Oil and mineral extraction in the Orinoco Delta Amacuro of Venezuela.	Environmental degradation, health effects, socio-economic impacts.	(Mantovani, 2017)
Oil extraction in Niger Delta Nigeria	Oil spillage, gas flare, environmental and human health effects, micro-climatic changes, inequity in cost and benefits distribution, conflict.	(Watts 2004; Ross 2006; Odeyemi & Ogunseitan 1985; Nduka et al. 2008; Orisakwe et al. 2001; Osuji et al. 2010; Ana et al. 2010; Ekpoh & Obia 2010; Ite & Ibok 2013; Donwa 2011; Obinaju et al. 2014)
Oil extraction in the Oriente region of Ecuador	Human health effects, environmental degradation, conflicts.	(Finer et al., 2008; Hurtig & San Sebastián, 2002; San Sebastián & Hurtig, 2005; Zaidi, 1994)
Oil extraction in the Brazilian coastal regions	Oil spillage; environmental pollution (terrestrial and aquatic).	(Da silva, Pes-Aguiar, Navarro, & Chastinet, 1997; Zanardi, Bícego, & Weber, 1999)
Oil extraction in Caspian and Karaganda region of Kazakhstan	Human health effects; environmental impacts.	(Dahl & Kuralbayeva, 2001; Netalieva, Wesseler, & Heijman, 2005)
Kola Peninsula, Pechora Basin of Russia	Pollution of waterways (lakes and bays), forest degradation, land pollution, micro-climatic impacts.	(Kuemmerle et al., 2014; Reimann, Halleraker, Kashulina, & Bogatyrev, 1999; Rigina, 2002; Walker et al., 2009;

Region and Activity	Associated Problem	Reference
		Walker, Crittenden, Young, & Prystina, 2006)
Chaco Region of Bolivia	Environmental impacts, cultural threats, conflict.	(Bebbington, 2014; Bebbington, 2013; Perreault & Valdivia, 2010)
Coatzacoalcos and Tonalá Rivers Low Basin of Mexico, Gulf of Mexico.	Oil Spillage, environmental impacts, human health effect, and conflict.	(Farrán, Grimalt, Albaigés, Botello, & Macko, 1987; Mendoza-Cantú et al., 2011; Vázquez-Luna, 2012)
Papua New Guinea's	Destruction of virgin rainforest and wetlands, aquatic pollution from toxic chemical deposit; distribution inequity and cost, conflict.	(Hettler, Irion, & Lehmann, 1997; Hilson, 2002; Swales, Storey, & Bakowa, 2000; Walton & Barnett, 2007)
Mining in Australia	Environmental degradation, human health effect, cultural threat.	(Ciaran O'Faircheallaigh, 2008; Weng, Mudd, Martin, & Boyle, 2012; Wright, Wright, Graham, & Burgin, 2011)

Although these examples were neither systematically chosen nor exhaustive with respect to regions, activity and/or problems; they serve as an illustration to show that resource extraction in these regions has been a challenge for communities, investors, policy makers and regulators and has evoked the sustainability debate amongst stakeholders.

4.3 Resource Governance and Management

Natural resources and the environment exist in a complex socio-ecological structure Ostrom (2009) with interaction between nature, technology, and people. High levels of technological, economic and geological complexity characterise mineral extraction and influence intertemporal decisions Barma et al. (2012) that cuts across scales (spatial-temporal) and sectors (environment, social and economic). The intertemporal and sectorial interactions evolve to enhance benefits derived or increase cost and environmental burden. Mineral resources management have been historically a complex activity, with mineral extraction paradoxically a double-edged activity framed around economic development and environmental protection whilst historical episodes of mineral extraction reveal inherent linkages and organic connection between extractive activities and society as it holds economic potential that can sever a society from the constraints of nature (Bridge, 2004).

Acheson (2006) demonstrated three possible governance structures in resource management; provided by private property, government and community management. He argued that there is no cure-all solution to resource management; that is, while each of the groups can succeed, they can also fail depending on prevailing circumstances. Tarui (2015) in his work presented institutional management arrangements that include state property, private property, common property and open access resources management. He furthered his concept arguing that any of the institutional controls that predominate depend on the need and scarcity of the resource. It is noteworthy that mineral resources are the driver of most economies especially in developing countries (Azapagic, 2004) whilst most developed economies advanced their economies on the exploitation of mineral and energy resources (Bridge, 2004; Kumah, 2006). From Tarui's argument (Tarui, 2015), there is an overarching aim for resource exploitation; that is to meet states' economic needs. Examples of such states controlling mineral resources are oil and natural gas in Nigeria; oil, natural gas and diamond in Angola; oil and natural gas in Brazil; oil, natural gas, gold and diamond in Russia; diamond, copper, nickel, and gold in Botswana.

Mining operations function within the formal and informal institutional frameworks of the country which hosts the mining project, and therefore inevitably acquire a political dimension, as well as strong links to its economy, ecosystem, and local communities; while the latter almost inevitably comes to depend on minerals production for employment, income, and broader development (Spitz & Trudinger, 2008). Observed in some of the regions of mineral assets is lack of an appropriate holistic framework to manage resources to enable delivery of desired benefits, minimise ecological decay, trade-offs and cost borne by host communities. Resource extraction is multifaceted and has political, social and economic implications (Kaup, 2008). Natural resources shape and are shaped by political context, with numerous examples from mineral-rich countries demonstrating this across the world. This includes the 'making and unmaking' of laws and policies governing resource ownership and extraction. Examples include cases from Angola (Reed, 2009), Bolivia (Bebbington, 2013), Ecuador (Perreault & Valdivia, 2010), Nigeria (Watts 2004; Ako 2009), where policies have been designed to disenfranchise land owners of property rights to subsurface resources (Aaron, 2012) through nationalisation and appropriation of natural resource wealth. It is noteworthy, that resource management, despite not being an exclusive reserve of national governments, has been under its purview in order to meet economic needs of states through taxes and resource rents (Netalieva et al., 2005; Nzimande & Chauke, 2012; Punam et al., 2015). The role of governments in resource exploitation and management has engendered counter posing challenges since the government is apparently locked in opposing and conflicting interests; agents of economic development and of custodians of the environment (Ascher, 2001; Puppim de Oliveira, 2000).

Generally, presence of stock of natural resources attract diverse interests and multiple players; including international investors, national governments and local communities (Kaup, 2008; Rodela, 2012) resulting in multiscale and diverse interactions that are complex and often become problematic. Studies have been conducted at different scales: national, community and site levels to investigate the omnipresent problem attendant with resource extraction and to evaluate traditional management approaches, however, parallel studies at regional levels looking at interactions in a more holistic way are comparatively limited. Finer and colleagues (Finer et al., 2008) advocate that study at regional level provides an avenue for proper delineation and for resource extraction to be coupled to other systemic impacts including characterization of extracting regions while Solomon (Solomon et al., 2008) posit that it improves governance structures while engendering sustainable development. Furthermore, sustainable development is usually addressed at regional scales where the region is defined with context to ecoregional scale of analysis (Bossel, 2003). Traditional management approaches place emphasis on economic rationality and environmental impact mitigation measures that are ad hoc, monodisciplinary and neither integrated nor holistic, thus the primary cause for the prevailing environmental problems we are left to deal with today. Robust management must take cognisance of the uncertainties and ambiguities not considered under the traditional economic driven approach. Coria and Sterner (Coria & Sterner, 2011) have argued that environmental sustainability and economic prosperity present a scenario that is only comprehensible from a multifactorial perspective whilst acknowledging that resource development and environmental stewardship are not mutually exclusive. The ecological decline coupled with the socio-economic and political exclusion of communities in MARs demonstrate that traditional environmental and resource management approaches have failed to favour policy regimes that balance environmental and social components as non-mutually exclusive components of development. These shortcomings have prompted the development of unconventional approaches with the objective of ensuring sustainable resource extraction and maintenance of environmental quality. This has operated under different nomenclatures although with the same core objective prompting research from both the academia and public sector to embrace the Ecosystem Approach (EA) as an effective approach to natural resource and environmental management. The report of the Millennium Ecosystem Assessment (MEA, 2005) bolstered the EA and has been instrumental in broadening knowledge and improving policymaking, however, emphasis on natural resource management has been on biodiversity in contrast to geodiversity (Gray et al., 2013). This position may have prompted Frank and co-workers (Franks, Brereton, & Moran, 2009) to argue that terrestrial minerals are part of the ecosystem of which its extraction brings disturbance to the natural environment compared to other ecosystem resources such as fisheries or timber. The Integrated Resource Management (IRM) also evolved with aspects on social, economic, technical and institutional programs to ensure a robust resource management outcome; however, Bellamy and colleague (Bellamy and Geoffrey, 1999) argue that fragmentation and lack of a multi-disciplinary view, high dependence on engineering, biophysical and economic standards tend to limit its application.

The need to manage the balance between mineral exploitation and environmental management has led to the formulation of management tools (legal or regulatory standards and fiscal regimes) to ensure a sustainable extractive regime on MARs. This has its limitations (Netalieva et al., 2005) as regulatory standards are often about the need of management systems rather than requirements that characterise the system per se (Hoyle, 2009). Cumulative socio-environmental and economic impacts of extraction and associated uncertainties is a real challenge to institutions of government and has drawn concerns across mineral dependent economies (Solomon et al., 2008). The absence of sustainable solution as documented in most MARs is clear evidence that the problem has either not been understood by resource managers and policy makers or the right tools have not been deployed to understand and manage MARs from a systems perspective. Depleting natural resource coupled with environmental degradation arising from mineral extraction in MARs demonstrates the need for a change from current management practices and policies towards an integrated, holistic and purpose-driven approach to improve the environment and ensure resilience and sustainability in these regions. Table 2 compares some features of traditional and systems-based perspectives. Understanding the characteristics of the system could create foundational knowledge for systems application in other to incorporate unconventional economics in the profit-seeking equation attendant with resource exploitation thus ensuring a sustainable MAR.

Table 4.2 Traditional management approaches compared to systems-based approach.

Traditional thinking approach	Systems thinking approach
Emphasis on conventional economic rationality	Based on sustainability and seek sustainable way out to persistent problems
Rent-based	Interest-based
Sectoral, reductionist and lack of multi-disciplinary view	Integrated, holistic and use of multiple perspectives
High dependence on engineering and biophysical standards	Understanding roots problems through soft approaches, and based on client perspective
Emphasis on regulatory standards	Emphasis on management systems
Exclusion, top-down and end-of the-pipe modus operandi	Integration, inclusion, collaboration, bottom-up and advocates win-win solutions
Confounded by complexity	Understand and manages complexity by thinking broadly to see interactions
Focused on managing resources and meeting policy target	Manage resource by managing people and their interactions resulting in learning outcomes
Technical and expert knowledge-driven	Stakeholder-driven and based on participatory approaches
Results in depletion of natural resource and environmental degradation	Aims to ensure resilience and sustainability of natural resources and environmental protection

4.4 Discussion

Mineral resource extraction engenders multiscale interaction between different stakeholders with economic gains and opportunities whilst being coupled with environmental and social impacts that evolve over time (Moser, 2001). Natural resource management is characteristically complex and therefore a constraint to sustainable development (Rammel et al., 2007). Resource-environment-economy interactions in a MAR are characterised by uncertainty and cognitive limitations that create complex incentives for policy. Moreover, ecological and geological interactions mediated by humans in the quest for mineral exploitation have created complex environmental, resource and sustainability problems that are chronic and defy traditional thinking that does not take cognisance of these interactions in a holistic way. For example, environmental, economic and social impacts of extraction have multiple and generational effects on both spatial and temporal scales (Franks et al., 2013). Therefore, there is a clear need to harness and operationalise complexity instead of ignoring it as complexity should not be considered a threat but an opportunity (Axelrod & Cohen, 2000). The emergent environmental and socio-economic characteristics of MARs occasioned by mineral extraction coupled with the traditional management approaches that are sectoral and monodisciplinary creates a complex situation because of the narrow focus on economic rationality that does not allow understanding of long-term, integrated and systems management approaches. Addressing this complexity, there is an overarching need for retrospective understanding, scenario analyses and futures thinking as to understand the complex nature of interaction that exists in MARs, before any solutions are derived to manage natural resources. A conceptual diagram of the environment-social-economic nexus that exists in mineral active regions is presented in Figure 1. Addressing resource management challenges requires an understanding of the complexity of the MAR system by looking at the interactions and relationships between all parts and redefining the challenges first by instrumenting the variables of interest to solve environmental and socio-economic problems attendant with mineral extraction. The conceptual diagram is a rudimentary attempt to show how extraction of any ecosystem resource can have attendant impacts on environmental, social, and economic components of the mineral active region system.

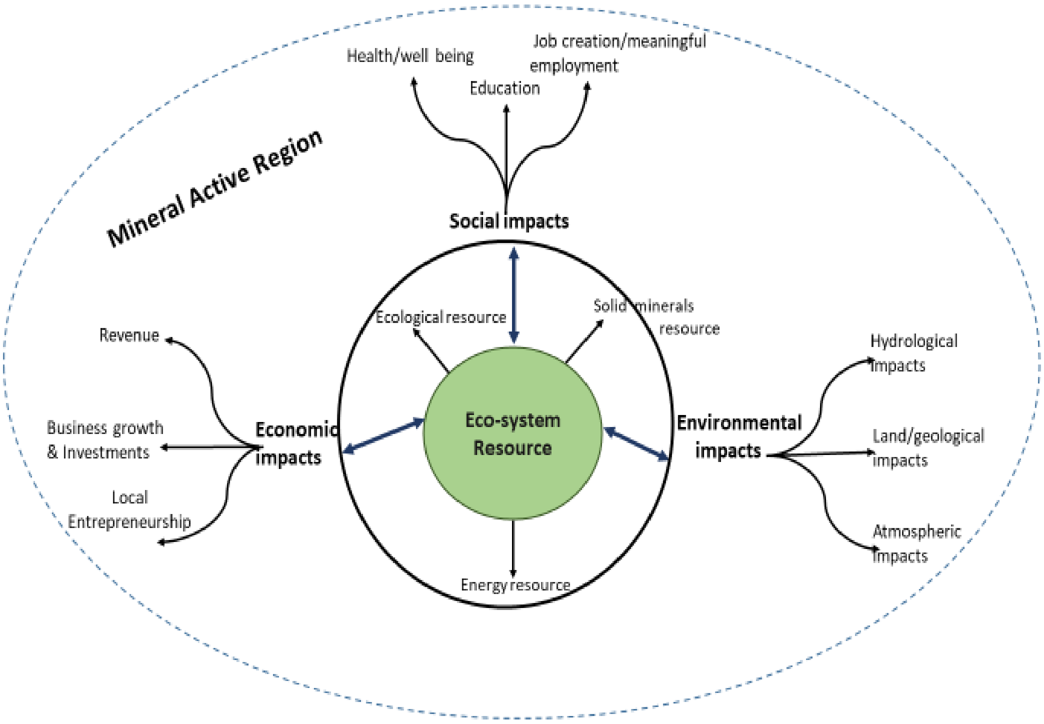

Figure 4-1 A preliminary generic conceptual model of ecosystem interactions.

A holistic way to understand resource constructs is by its function and relationship (Solomon et al., 2008). This view sheds light upon an organic connection between humans, the environment, the economy and natural resources. Problems associated with resource extraction cannot be attributed to the latent subsoil assets but the conditioning circumstances and configuration of interest that have developed around its exploitation (Collier & Hoeffler, 2005). As a matter of fact, one of the prevailing problems confronting environmental managers and policy makers is the holistic integration of economic activity with environmental, social, political and administrative issues which is hinged on effective governance regime (MMSD, 2002; Petak, 1981). Solving environmental problems associated with resource extraction lies in understanding roots problems, reaching optimal policies and engaging technical solutions (Stave, 2010). For example, problem structuring methods that are participatory could enable understanding of the causes of problems (Mingers & Rosenhead, 2004) as against the top-down and black box techniques that are characteristic of traditional approaches. Managing natural resources is about managing people rather than the resource (Ludwig et al, 1993). Inability to account for micro-level decision making in designing policies may result in a policy-resistant scenario where the system's response to the policy implementation defeats the design purpose. Observed in many MARs is a complex yet non-inclusive resource management structures that have led to misperceptions and misrepresentations of actions of extractive companies and host communities resulting in community loss of faith in multinational extracting companies for disenfranchisement and for inability to influence issues concerning their future (Ballard & Banks, 2003; Hodge, 2014). This makes it phenomenal to see blame trading amongst the international extracting companies, local communities and the government often resulting in conflict with reputational liabilities (Aaron, 2012). Some scholarships however consider conflict an integral part of the resource extraction regime (Hodge, 2014). Bebbington (2014) explored this view by arguing that conflict can bring change that will enhance performance and that improved performance might deflate conflict. The theory offers a paradoxical interpretation though, one that subsists, however, a question that comes to mind would be: why should it take conflict situation to advance environmental policies that could change management approach? The conflict-driven change is tenable when the interaction and conflict results in a condition and learning process that could lead to diminished conflict and improved performance otherwise it can set in motion a chain of counterintuitive state of physical and moral warfare with reputational and economic consequence.

Management must therefore consider varying interests that configure around resource systems by incorporating stakeholders' perception into decision making in order to manage different stakes that are attendant with resource extraction. Management that is not holistic in problem conceptualisation and participatory in solution design can result in lasting environmental and social impacts (Canberra, 1995). For example, after extensive research in the Niger Delta region of Nigeria; (Jike, 2004) demonstrated that current resource extraction patterns if uncontrolled may constitute irreparable damage to regional ecosystems by leaving an 'irretrievable' footprint on the environment as well as socio-economic elements. Most of the studies conducted (for example in the Niger Delta Nigeria) are sectoral and reflect discipline bias, either looking at environmental contamination and ecosystem effects arising from extractive activities (Nduka et al., 2008; Obinaju et al., 2014), biophysical effects (Ekpoh & Obia, 2010; Salako, Sholeye, & Ayankoya, 2012) or socio-economic dimensions (Adesopo & Asaju, 2004; Ipingbemi, 2009; Netalieva et al., 2005). Environmental issues should be considered an administrative predicament that must be holistically understood and not the reductionist and discipline-oriented approach that is ineffective and incomprehensive at managing resource and environmental complexities (Roseland, 2000). Environmental quality and natural resource management are inseparable factors that should be dealt with in an integrative system without setting arbitrary socio-economic or political boundaries. Resource development and environmental stewardship are not mutually exclusive as they can be simultaneously coupled with responsible resource management effort underpinned on robust policy and effective regulation and can be undertaken to bring a maximum economic contribution and improved social condition with minimal environmental damage (Kitula, 2006). This can be achieved if resource regimes shift from reductionist rent-based to a holistic interest-based approach that is focused on ecological integrity, sustainable mineral extraction, community rights, redistributive equity, and futurity. The need for systems thinking in understanding and managing complexity in MARs and delivering sustainable development is clear.

Systems thinking is an important cross-sectoral, interdisciplinary and diagnostic tool to understand interactions by improving communication and providing information on the vulnerabilities and resilience of a system as to avoid policy resistance and system collapse. The sustainable environment and resource regime aspiration underscore the need to understand interdependences in mineral resource systems and how that can be leveraged to deliver win-win solutions for both the environment and society. Traditionally, developing environmental management plans has been the domain of highly trained experts, however, this approach has been perceived to have led to a number of failures and counterintuitive outcomes because of its mechanistic and non-deliberative approaches. Moreover, conventional policy regimes that evolved from technical domains over long timescale to address environmental and natural resource problems are too deterministic, mechanistic and not adaptive to address multiscalar and cross-sectorial problems confronting this generation (Lockwood et al., 2010). Management approaches that are focused on quantifiable and measurable impacts (Franks et al., 2013) without consideration of the elemental relationships and interactions that reflect technical and soft principles underpinned by stakeholder constructs and interests. Systems thinking is purposed to advance environmental decisions that are robust (Laurenti, 2013) since it is conceptual and contextual and involves thinking, collection of data from clients, integration of stakeholders' mental models and communication. Consequently, this approach can reduce the opacity that expert or technical driven approaches present.

Systems thinking, and equation-based system dynamics are central to tackling complex problems and has been widely applied in different fields including medicine and public health (Mccubbin & Cohen, 1999; McSherry, 2004); natural environment (Bunch, 2003; Marshall & Brown, 2003); farming system in agriculture (Kropff, Bouma, & Jones, 2001) and sustainability of wind renewables (Tejeda & Ferreira, 2014). Interactions in mineral active regions make them inherently complex, therefore, evidence-based knowledge is required in complex problem management to enable effective and result oriented outcome. In this work, we propose the soft systems approach (Checkland, 1988; Checkland & Haynes, 1994; Petak, 1981) which is principally qualitative, however, quantitative data would be explored to gain an understanding of behaviour over time of activities in the region of interest. The qualitative approach allows unquantifiable or soft variables that influence environmental and resource decisions to be objectively captured (Laurenti, 2013). The approach is participatory and allows for creative problem structuring and embedding of stakeholder interest (Reed et al., 2009) by raising our thinking to become aware of the consequences and benefits of interactions. This is achieved through mediated or group model building and involves the use of mental models, conceptual models, situation mapping and rich pictures to scope, elicit information, build consensus, deconstruct complexity and consequently create the results that we want. Realising that people's perception and understanding of things differ even when describing the same issue validates the need for transdisciplinary participation of stakeholders to enable collective representation and integration of different perspectives so as to improve overall understanding of the system and ensure the sustainability of the mineral active regions through shared knowledge (Magner, 2011).

Generally, environmental problems bordering resource extraction permeates every discipline and sector; it is, therefore, necessary for discipline-based and reductionist knowledge to subordinate transdisciplinary ideas which are broadly based and holistic. To facilitate this, a conceptual model for a MAR, with defined system components/variable (type of natural capital, natural resource accounting mechanism and principles, management institutions, environmental quality, biodiversity and ecosystems, geotechnical features, geopolitical condition, local and regional economy, socio-cultural features, human health effects) subsumed in the environmental, economic, social, and institutional sustainability tetrad is presented in Figure 2 as a representation of the systems view of a mineral active region. The main purpose of this conceptual model is not to analyse the interactions but to bring to bear through robust literature review some of the less known systems components of a MAR that interact either directly or indirectly to occasion management and sustainability problem.

Systems thinking is therefore proposed as a methodology worth investigating for the management of MARs, as it offers the potential for ensuring a sustainable environment and resource regime that deliver benefits to all stakeholder while maintaining ecological integrity as an alternative to the traditional reductionist thinking approach.

Figure 4-2 The conceptual systems representation of the components of a MAR.

4.4.1 Explanation of concepts

The concepts represented in the conceptual model presented in figure 4.2 is explained in the subsections.

4.4.1.1 Type of natural capital

Natural resources base can be classified as renewable or non-renewable. In a general, it is the sum of crop, pastureland, timber, non-timber, forest, protected areas, oil, natural gas, coal, and minerals. It can be classified as "point-source" (Alexeev & Conrad, 2011; Isham et al., 2005), "fugacious" and or "diffuse" (Aladeitan, 2013). These classifications relate to the physical characteristic and ownership. Oil and gas are considered "fugacious" (Aladeitan, 2013) because they are viewed from the perspective of a migratory subsoil resource. Natural resources constitute the natural capital that contributes to the flow of goods and services to the economy through the inputs of raw materials and energy resource or through transformation to final products and services. Economic rent has been designed to place a value on natural capital (Kunte et al. 1998). In this thesis, the focus is on subsoil assets which refers to oil, natural gas, coal, and minerals but in applying the conceptual model to the case study the concept is limited to oil and gas resource.

Resource Rents = Production x Unit Rent = Production x (Unit Price – Unit Cost)

Exhaustion time = Years to depletion (or, life of resource) (reserves/current production), capped at 25 years

Resource wealth = Net present value of resource rents, discounted at 4%, over exhaustion time.

Depletion = Resource Wealth / Exhaustion time

4.4.1.2 Natural Resource Accounting

Economic development of subsoil assets through resource exploitation generates resource rents which are used to meet economic needs especially for mineral dependent states. Conventional national accounts that focus on market transactions and indicators are limited and does not capture the full resource dynamics such as depletion of resource stocks, environmental degradation, and ecosystem services losses. The increasing awareness of environmental issues led to a conclusion on the need to establish practical measures that natural resources should be treated as valuable assets, therefore valued in monetary terms (Uberman, 2014). Frameworks have been developed to guide proper resource accounting methods and this includes System of integrated Environmental and Economic Accounts (SEEA) which evolved from the Handbook of national accounting: Integrated environmental and economic accounting (United Nations, 1993). The United Stated was the foremost to attempt to include natural resources in their accounting system with Harald Hotelling on its frontiers (Uberman, 2014). Although this is no longer a common practice in the US, more recently, Norway has made attempts to include natural resource in its accounting systems (World Bank, 2011). In developing the conceptual model, attempt has been made to recognise the importance of the concept of natural resource accounting that is mostly ignored in many developing countries whose economies are mainly dependent on rents and taxes generated from mineral resource extraction and export. In my view, a comprehensive resource accounting system potentially can result in sustainable development.

4.4.1.3 Geopolitical Condition

There is a political dimension to mineral resources issues with regards to resource exploitation, transformation and consumption (Le Billon, 2007). Many critical resources are located in contested or unstable regions (Klare, 2013) and protection of supplies of vital resources is important because an interruption in supply would portend severe economic consequences for both exporting and importing nations. Many states view the control of critical natural resources as a national security obligation. Therefore, global resources like oil and gas and minerals have created a trend for policy making by nations to maintain supply of resources including trading power from a geopolitical perspective. Economic globalisation would continue to influence global power dynamic and the presence of such critical resources puts host nation on global view (Watts, 2004). Therefore, any discourse on MAR must consider the geopolitical condition surrounding critical global natural resources.

4.4.1.4 Geotechnical Features

Mineral extraction involves high levels of technological, and geological complexity and all extractive activities involves physical landscape modifications (Bridge, 2004). Mineral extraction involves earth movements to allow for geological survey, exploration, extraction, and beneficiation while for oil and gas extraction, the project is multi-faceted with different phases, such as land clearance for seismic lines, establishment of seismic, acoustic emission, infrastructure construction, and drilling for oil. Decommissioning, rehabilitation and site restoration. This process also involves the use of technology to increase and optimise production and to reach resource deposit that are not easily accessible. The geotechnical features surrounding the extractive use of the environment inherently impacts MARs and can be conducted in a sustainable or unsustainable manner. In discussing MAR, it is important to highlight the geotechnical component of a MAR because of its significance in the extractive sector and associated activities in a MAR.

4.4.1.5 Local/Regional Economy

Mining projects and operations take place in communities and regions of mineral wealth. Such operations establish a strong link to its economy and local communities as they depend on minerals production for employment, income, and development (Spitz & Trudinger, 2008). The local and regional economy is influenced both direct and indirect impact of extractive activities including cost and benefits distribution. The presence of subsoil resources could increase the local and regional economy depending of the forward and backward links of the extractive activities to the economy of the region as well as the redistributive mechanism in place to manage natural resources wealth.

4.4.1.6 Management Institutions

Mineral extraction has strong political context because it is shaped by formal institutions as well as non-formal institutions. In many regions of the world, the ownership of subsoil resources is vested in the state while in some, it is based on private ownership. In some places, government owns, extracts and regulate natural resources while in other regions, government's involvement as the owner is limited to regulation. In the Niger Delta Nigeria, poor management from managing institutions is blamed for being responsible for the unsustainable extractive operations since government screens operators and multinational oil companies from hostile intervention in order to ensure unhindered access to oil wealth (Ebeku, 2004; Ugochukwu & Ertel Jürgen, 2008). Institutional quality is fundamental in shaping the activities in a MAR including ensuring the sustainability of such regions.

4.4.1.7 Environmental Quality

Mineral extraction inherently come with significant environmental effects through generation of waste and contamination of host environment (Rourke & Connolly, 2003). For example, air pollution, toxic waste emission, oil spills, gas flaring, drill waste is common in regions of mineral/oil and gas extraction. Extraction activities are characteristically invasive and affect ecosystems (Rourke & Connolly, 2003). Impacts includes negative atmospheric and hydrologic effects as well as contamination of lands in the vicinity of extractive activities (Ite & Ibok, 2013). The consequent degradation of the environment due to extractive activities raises huge public concern with a space for policy instruments for managing the complex and omnipresent environmental cost of extraction.

4.4.1.8 Human Health Effects

The impacts of extractive activities on human health can be significant and with detrimental effects. Extraction can lead to a range of acute and chronic health impacts through the exposure of naturally occurring hazardous materials, toxic dust from mining or contaminated soil which incidentally can be a reservoir of wastes and contaminants. This can affect the health of humans through direct contact or through ingestion or inhalation. Acute exposures to aromatic hydrocarbons, which are the basic constituents of oil, are known to cause respiratory symptoms (Gobo, Richard, & Ubong, 2011; Suárez et al., 2005). High molecular weight PAHs are known to have mutagenic, and carcinogenic effects and bioaccumulate in organic tissues due to their lipophilic character (Ite & Ibok, 2013). Negative human health effect is a known consequence of extractive activity in a MAR.

4.4.1.9 Biodiversity and Ecosystems

From an ecosystem perspective, extractive processes can affect ecological processes in the receiving environment. Such interactions portend serious implications for ecosystem function and ecosystem health (Bridge, 2004). This includes the biological productivity of receiving ecosystems and the ecosystem services they provide. It can affect wildlife, both aquatic and terrestrial (Ebeku, 2004; Ugochukwu & Ertel Jürgen, 2008). Extractive processes can exert indirect effect on biota or their host environment. For example, water ecosystems by changing the physical and chemical characteristics of the environment.

4.4.1.10 Socio-cultural features

Regions of mineral/energy resource extraction experience socio-cultural intrusion. The process of extraction involves seismic activities, building of road, rails, and pipelines for oil exploration in remote environments which threaten survival of communities and isolated indigenous peoples through accessing of aboriginal lands and sacred sites (Ciaran O'Faircheallaigh, 2008; Sosa & Keenan, 2001). Presence of extracts activities impacts upon the original occupations of indigenous people most of the times, changing fundamentally the cultural autonomy of such groups. The cultural and social distortion of these regions can result in conflict which includes conflict with indigenous groups over oil development, civil unrest, terrorism targeting oil facilities (Rourke & Connolly, 2003). Also, occupational communities/workers face stress from long shifts and social isolation.

4.5 Conclusion

Investigating the systemic effects of mineral extraction in MARs; their contribution to the economic liberation of nations, attendant environmental and social impacts as well as the effect on the geopolitical landscapes of countries with natural resource assets, the complexity of these regions is clear. Mineral extraction draws divergent interests and affects stakeholders differently in terms of cost and benefits distribution whilst studies have shown that extractive industries' successes are ensured when corporate interest is aligned with regional and community interests and values. The awareness of the interdependences between the various players and sectors ensure inclusivity and collaboration that could lead to a sustainable extractive regime (Esteves, 2008). Key factors that beset MARs are weak laws and a bad resource governance regime together with the reductionist, monodisciplinary and rent-based rationalities. Addressing the complexity of mineral active regions, system thinking has the potential to deliver benefits by analysing the links between components of the systems, their interaction, and interdependences in an environmental management system. Using conceptual models of the relationships and interactions that characterise the overall system, a multidisciplinary environmental approach is required to understand the system and empower stakeholders to see the interactions and interdependencies. Through the application of a systems approach, critical gaps that undermine efforts to sustainable resource extraction and environmental management of MARs become visible. The gap of complexity, uncertainty and the reductionist end-of-the-pipe thinking that characterise traditional environmental policies. The proposed systems thinking approach would be broad in perspective accounting for spatial-temporal and sectorial issues. The approach is participatory and involves gathering historical and contemporary views on MARs by creating a collective representation and integration of different perspectives in order to improve overall understanding of the system based on collaboration and stakeholder holder inputs. Systems based methodologies view mineral active region as a catchment bearing in mind that physical systems are open with spatial and temporal boundaries. This does not mean that that systems-based methodologies would provide an all-encompassing solution, instead, this approach and its inclusive structure offer insight into environmental and natural resource challenges that could redefine the problems and even make the need for management initiatives obsolete.

Chapter 5

"We can't solve problems by using the same kind of thinking we used when we created them".

Albert Einstein, Physicist, 1879-1955

Systems thinking helps to raise our thinking level to create the right interaction as to produce the right results

5 Research Design and Methodology

Conducting research consists mostly of two parts: the research focus and the questions the research aims to answer (Robson, 1993). Research designs could take different forms but three types are generally recognised: qualitative, quantitative, and mixed method (Denscombe, 2010; Robson, 1993). According to Creswell (2009) research design is underpinned by philosophical assumptions, inquiry strategy and methods. These philosophical assumptions are positivism/post-positivism, constructivism, participatory and pragmatism. The positivist/post-positivist is a deterministic approach to research and is based on observed, measured and verifiable knowledge. Its objective underpinning is informed by critical realism and generalisable application. It uses quantitative and experimental techniques to arrive at objective findings (Creswell, 2009; Crotty, 1998). The constructivist is subjective in its enquiry approach and it is based on constructed realities (Creswell, 2009); this makes reality a social construct and knowledge subjective. It employs the qualitative methodology through mainly interviews, participant observation (Creswell, 2009; Crotty, 1998). The philosophical underpinning of the post-positivist and constructivist research strategy allows for quantitative and qualitative data respectively and not flexible to allow the mixed data application. Participatory and pragmatist methodologies support application of both qualitative and quantitative methods. However, research questions and aim are key factors that influences a researchers' choice of method.

In this research, the case study approach is chosen as a research strategy because it generates new hypothesis that will make contribution to knowledge about MAR. A case study approach has been used extensively in research for many reasons which according to Noor (2008) aims to focus on specific feature, issue, or unit of analysis. The case studies approach is premised on finding out the cause of things and exploring realities within the context of interest so as to understand what actually happened as against what was intended to happen (Anderson, 1998). It provides circumstantial evidence of temporal and spatial relationships within the problem context and exemplifies the concept of thinking globally and acting locally. The Niger Delta, Nigeria is an example of MAR and represents a region characterised by multiple actors, perspectives, and conflicting interests with a legacy of complex interactions that has caused massive environmental degradation, economic losses, and social problems. Noor (2008) suggests that a case study approach allows for holistic understanding of the phenomenon or event of interest by the researcher. Noor's suggestion (Noor 2008) informs the choice of the ND region as a case study because the study aims for a holistic understanding of ecological, economic, and social interactions in the systems and how the interaction could present a sustainability problem in the region. Because this study is focused toward developing an approach that can shape environmental policy making and the management of MARs, we therefore reviewed several tools that aid decision-making in order to ensure the objective selection of the most suitable tool.

5.1 Review of Systems Decision-Making Approaches and Appraisal of Systems Tools

Environmental decision making need to be well guided and undertaken with confidence to achieve specific outcomes that are sustainable. Different decision making, and management tools employed in environment, resource, and sustainability studies such as Systems Thinking (ST), Stakeholder Analysis (SA), Drivers–Pressure–State–Impact–Response (DPSIR) and Multi-Criteria Decision Analysis (MCDA) were reviewed to demonstrate their suitability. Although these tools have applications in different fields of study, they have regularly featured in environmental studies. This chapter assessed the different approaches to show their relevance and effectiveness in environmental policymaking. Considering that many environmental and resource problems are complex, unstructured, long term and involve trade-offs, it is therefore important to select a tool that can address these challenges.

5.1.1 DPSIR Framework

The driver–pressure–state–impact–response (DPSIR) framework is a causal chain-like phenomenon of interaction from origin to consequences of environmental problems. The framework was improved from the earlier framework (Rapport & Friend, 1979); the Stress-Response Environmental Statistical System (S-RESS) by the Organisation for Economic Co-operation and Development (OECD, 1993) and was further enhanced and given clarity by the European Economic Area (Smeets & Wetering, 1999) through modifications. An important commitment of the OECD in the pursuit of sustainability was to ensure environmental decoupling from economic growth. Decoupling occurs when the environmental pressure growth rate is lower than that of its economic driving force for a duration. In common parlance, it is referred to as "breaking the link between environmental bad and economic good". The DPSIR framework connects key relationships between society and the environment, but its simplistic approach makes it unable to capture several underlying interactions without losing its simplicity as a communication tool (Adekola 2011). The DPSIR framework can be a practical tool for demonstrating the key relationship in a MAR but its usefulness and effectiveness is demonstrated when there exist enough data to engage with. Describing the causal chain from driving forces to impacts and responses for a MAR is a complex task because many of the links are indirect, not clear and difficult to unravel; however, DPSIR allows policy-makers to understand easily environmental problems and their links (Maxim, Spangenberg, & O'Connor, 2009) that could be obscured by complex scientific representation. To design effective programs intended to catalyse expected change from policy instruments, it is important to understand causality. According to (Bellamy, Walker, McDonald, & Syme, 2001), ambiguity is associated with cause-and-effect relationships in issues of natural resource management; however, this challenge can be overcome by holistic and context specific methodological adaptations. Maxim et al. (2009) acknowledge that there are different conceptual distinctions in vocabulary and application of the DPSIR in different disciplines, they proposed a methodology to unify the concept to reduce the fuzziness in the use of the framework. However, the DPSIR has been criticised as being deterministic (Maxim et al., 2009), which makes it unsuitable in dealing with complex problems which are characterised by feedbacks and non-linearities. The figure 5. 1 is a DPSIR framework applied to mining.

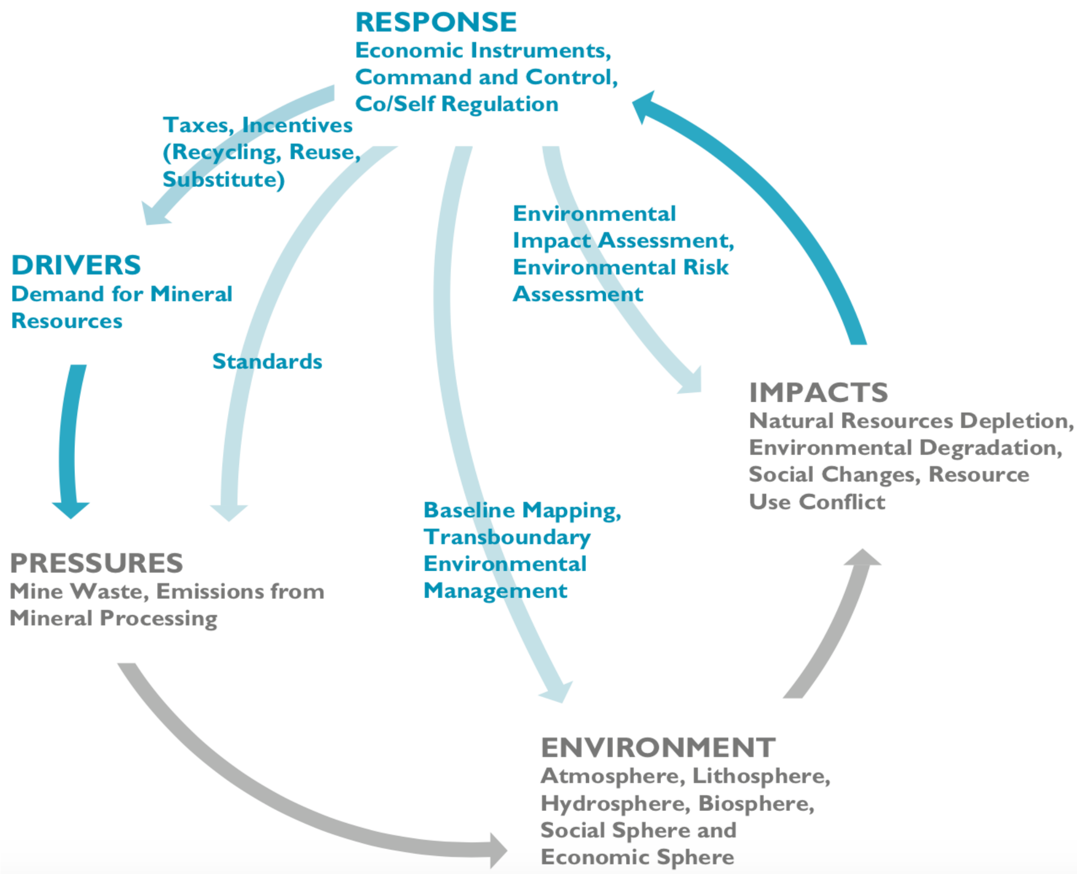

Figure 5-1 DPSIR Framework Applied To Mining. Source: (Spitz & Trudinger, 2008)

5.1.2 Stakeholder Analysis

Stakeholder Analysis (SA) is an approach to performing policy analysis, implementation, and development. It evolved to address the challenge of multiple interests and objectives in the development of policy and practice, however, the scale of the issue and context determines what approach to take. For example, local issues can take the form of interviewing of locals to generate information whilst for a transnational issue it can take the form of analysis of policy documents, reports, data (Brugha & Varvasovszky, 2000). It is useful in understanding key actors and stakeholder and to gain knowledge of a system (Grimble & Wellard, 1997). It is an approach to develop understanding and generate knowledge about the interest, behaviours, power, intentions of relevant actors and create strategies for management of stakeholders in policy development (Brugha & Varvasovszky, 2000). It can be applied in natural resource management as practical tool that helps in the representation of the different stakeholder interest. According to Reed et al. (2009) SA is seen as an empowering process in policy development in natural resource management to allow marginal stakeholders to influence process of decision making by understanding power dynamics amongst stakeholders. Policy making is shifting from the traditional rational policy making to a more inclusive stakeholder driven. The SA approach can be applied in the MAR context to identify stakeholders, their interest as well as power differentials, however, the process is best suited when the problem or policy issue is known, and short-term intervention is required (because of possibility of change in status or context) and importance of actors and/or their interest is also required. The interactions in MARs make them complex whilst confounded by uncertainty. Therefore, a clear definition of the problems becomes challenging which limits the application of SA. Although SA is an important approach that can be applied in identification of stakeholders in MARs, its application is limited in the management process. Moreover, uncertainty, imperfect knowledge, cognitive limitations makes SA difficult to represent complex social-ecological system emerging from the minerals-environment-society interaction.

5.1.3 Multi-Criteria Decision Analysis

Multi-criteria decision analysis (MCDA) is aimed at supporting policy making through the facilitation of a fair conversation about options that are different and competing for management purposes whilst taking into consideration the diverse views of stakeholders so as to be able to provide informed knowledge on the implications of choices or differing options (Schuwirth et al., 2012; Wang et al., 2009). The process allows for empirical quantification of uncertainties that are associated with complex problems characterised by conflicting objectives (Wang et al., 2009). According to Opricovic & Tzeng (2004) the approach present some advantages such as allowing the investigation and integration of the interests and objectives of multiple actors, provision of easily communicable outcome, allows for alternatives' assessment and objective inclusivity of different perceptions and interests. Although the approach results in a decision reached through an algorithmic process, it however, does not produce consensus because consensus is reached through gathering of information and viewpoints and synthesis of new ideas/information whilst reducing adversary disposition (Roseland, 2000). Even though this methodology is empirically driven to problem solving, it works best when the problem is known, and decision goals are established, and stakeholder already identified. Although widely used in environmental and sustainability decision making (Steele et al. 2008; Linkov et al. 2007; Sudhakaran et al. 2013; Cinelli et al. 2014), the reliance on experts/humans to assign weights to criteria can affect the overall quality of decision because it plays a critical role (Roszkowska 2013). That is, the reduction of a complex problem to quantitative metrics converged toward preferred solutions and a decision maker's preference can be limiting and reductionist. However, (Sinan Erzurumlu & Erzurumlu, 2015) overcame this by incorporating design thinking and MCDA to support sustainable development of small-scale mining development in Central America (Sinan Erzurumlu & Erzurumlu, 2015). MCDA can be applied in MARs when criteria for assessment is already established, and measurement output is needed to improve decision making. It is noteworthy that socio-environmental and economic interactions in a MAR results in complexity and influenced by number of factors — some of which are within human control whilst others outside human regulation. Therefore, whilst we acknowledge that MCDA can be applied in decision making in MARs, it is best suited when certain conditions are in place and/or simultaneously used with a supporting tool.

5.1.4 The Systems Approach

Systems thinking (ST) is an interdisciplinary research approach designed to combine knowledge from physical, natural, and social sciences (Cabrera et al., 2008). Systems thinking has three related but distinct attributes: paradigm, language, and methodology whilst the three paradigms that establish a system are purpose, elements, and interconnections (Arnold & Wade 2015). It means that a system must have a purpose and elements/components that interact. The system language is a set of powerful tools that helps to understand and communicate the observed systems behaviour using visuals, stocks and flows diagrams (Richmond, 1997). The systems methodology is generally categorised into hard and soft systems methodology. Pan et al. (2013) define a system as an integral of interacting components or elements that serve to achieve an expected function. That is to say, a system is not the sum of its parts but the product of their interaction insomuch as it has a purpose, and elements or components that are interconnected. Arnold & Wade (2015) encountered a lack of a holistic definition in the systems thinking vocabulary and, in a bid to improve definitional clarity, proposed the definition that "Systems thinking is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects". These definitions provide a premise for establishing that "A mineral active region is a system whose purpose is to ensure provision and sustainable use of natural resources and ecosystem services derived from them while preserving the structure, functioning, productivity, and diversity of the region". Systems thinking is a field of knowledge for understanding interactions, complexities, chronic systems problems, change and dynamic cause and effects over time. It can be considered as a framework for seeing interrelationships and patterns of change. In environmental research, a system is viewed over a range of scale with inputs, outputs, boundaries and interacting components. Tejeda and colleague argue that systems thinking allows for a holistic understanding of a system thus providing an enhanced understanding of systems behaviour (Tejeda & Ferreira, 2014). Mineral active regions generally have environmental, economic, social and institutional sub-systems and are characterised by complexity, uncertainty, and non-linear interactions. Complexity and uncertainty lead to surprises due to cognitive limitations which consequently limits the robustness of environmental policy making thus obscuring efforts that create lasting interventions.

Proponents of systems thinking advocate its criticality in addressing complex and unstructured problems. Complex systems such as those of water catchment, airshed are dynamic and difficult to understand (Franks et al., 2013) and confounded by spatial and temporal factors. Similarly, mineral active regions are characterised by spatial and temporal issues that are complex with conditions of uncertainty that complicate management. The inclusive fundamental approach of sustainability science demonstrates its influence on systems approach (Endress 2014), and in particular, targeted at understanding and managing natural resources including environmental and economic systems while (Kelly, 1998; Sanò & Medina, 2012) observes that its application is important in understanding and clarifying poorly understood systems' relationship. As an important cross-sectoral tool, it provides information on the vulnerabilities and resilience of a system and consequently help to avoid a system collapse. Environmental policy is inherently cross-sectoral, thus robust environment and resource policy decisions are based on a holistic understanding of the components in the system and their interaction (Daniels & Walker, 2012). This represents the view of Antunes et al. (2006) who maintains that environmental decision making should base on understanding interactions between ecological, economic and social aspects. Generally, resource problems are simultaneously viewed as environmental problems and characterised by several legitimate viewpoints (Steyaert & Jiggins, 2007). These legitimate views are divergent and sometimes antagonistic. To forge a consensus, stakeholders' views should be modelled in a goal-oriented design to achieve a solution where everyone benefits. According to Laurenti, systems thinking is purposed to advance environmental decisions that are robust Laurenti (2013) since it is conceptual Cabrera et al. (2008) and contextual and is based on holistic principles. Systems thinking has the potential of providing an engagement tool that shows interactions that will enable stakeholders to appreciate how actions or inactions can affect the whole system instead of the individualistic 'legitimate' perspectives that have reductionist outlook. It has the potential of deconstructing complexity that plagues mineral active regions and influence policy decisions by facilitating learning and management in order to ensure natural resource and environmental sustainability. Sterman, asserts that systems thinking is based on a holistic method for viewing complex problems, focusing on the interacting components of the system Sterman (2000) while Hjorth & Bagheri (2006) advocates a non-linear and organic way of thinking with attention placed on the whole. The systems approach maintains that to understand the function of the natural environment, priority must be placed on the whole of its parts or components. For a MAR, the components include subsoil assets, natural capital type, natural resource accounting, environmental quality, geo-political condition, geo-technical conditions, biodiversity and ecosystem, local and regional economy, human health effects, socio-cultural features. For each of the components, there are stakeholders who affect or are affected by the interactions in the system.

It is worth noting that quantitative systems tools such as dynamic modelling have been suggested as a complementary and mutually reinforcing approach that could corroborate soft systems thinking approaches in other to minimise subjectivity, reinforce systems based qualitative approaches while enhancing reproducibility which is a limitation to use of systems tools, however, both processes have methodical distinction. The dynamic modelling involves the use of a set of computer simulation software to rigorously connect systems structure to dynamic behaviour in a stock and flow pattern. Generally, soft systems methodology is a qualitative tool that enable unquantifiable variables that influence environmental decisions to be objectively factored (Laurenti, 2013). Soft tools that enable this include group model building, mediated modelling, causal loop diagramming, rich pictures, use of situation mapping and mental models to depict spatial, holistic and unspoken views of stakeholders' in systems conceptualisation (Daniels & Walker, 2012). An example of a rich picture and causal loop diagrams is given in the figure 5.2 and 5.3.

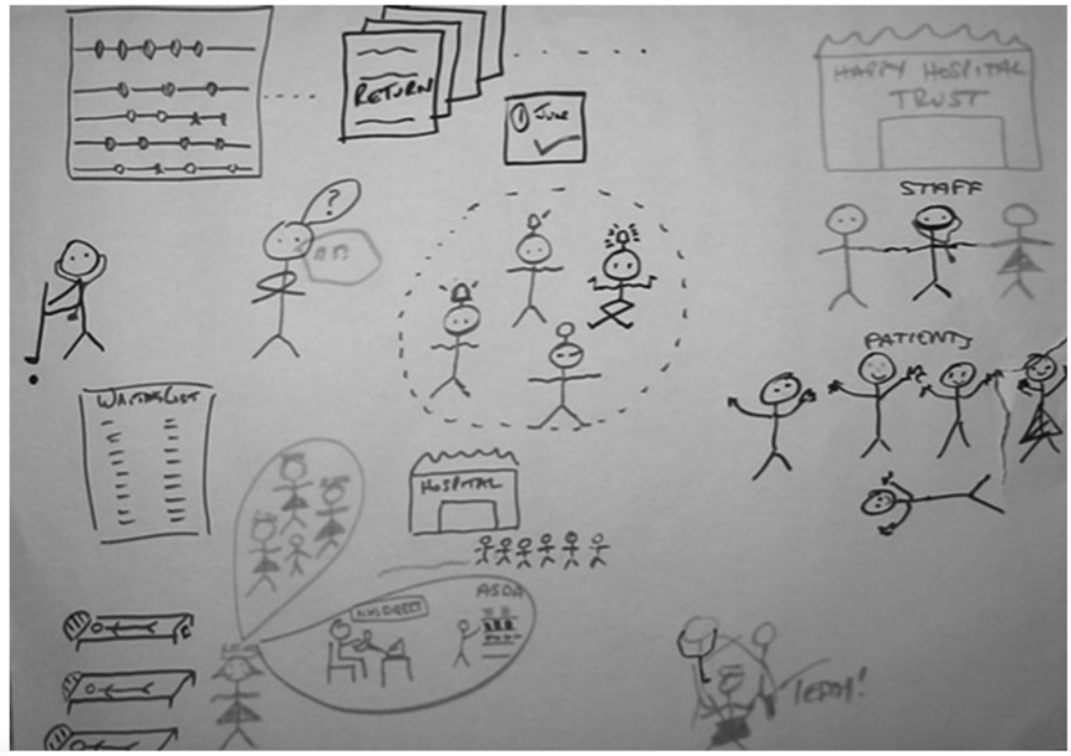

Figure 5-2 NHS Rich Picture. Source: (Bell & Morse, 2013)

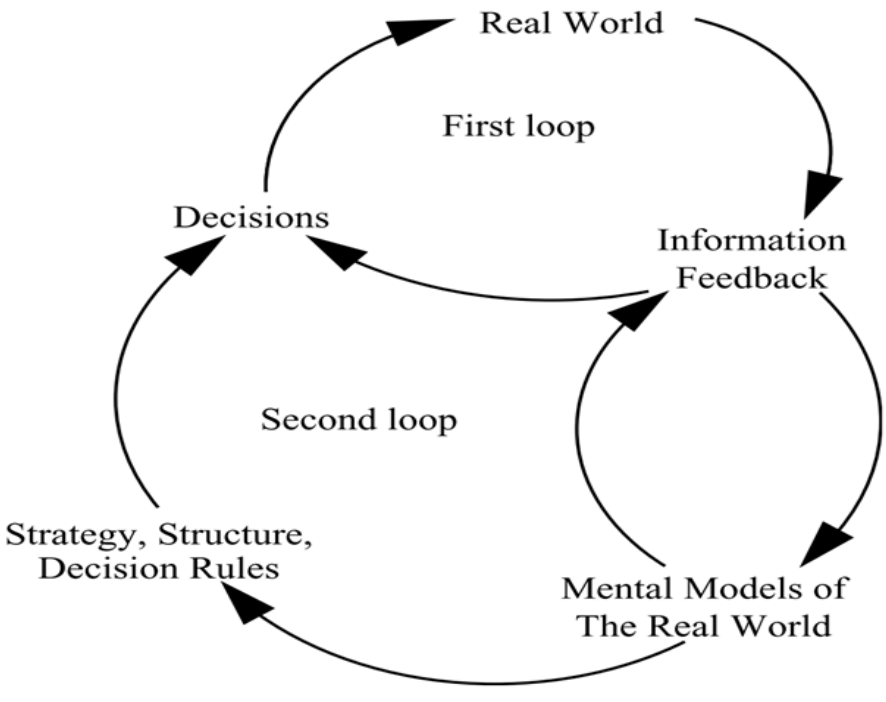

Figure 5-3 A Causal loop diagram showing a learning process (Hjorth & Bagheri, 2006)

Use of systems methodologies such as group model building is based on its participatory approach, which creates room for consensus-building, conflict resolution, transparency, legitimacy, buy-in and increases commitment towards decisions reached. It is noteworthy that in systems research, researchers in this field have established unique learning styles referred to as ‘archetypes’ according to their preferences. Some of the systems archetypes include: Limits to growth, Shifting the burden, Eroding goals, Escalation, Success to the successful, Tragedy of the commons, Fixes that backfire, Growth and underinvestment, Accidental adversaries, and Attractiveness principle. These are well understood and established systems behaviour that frequently recur and are the classic system stories that describe common patterns of behaviour. From the foregoing, a deduction supported by Seager et al. (2013) is that no single paradigm constitutes a systems approach as long as the principles of systems thinking are followed. The procedure would therefore depend on the skill of policy-makers and systems analyst.

Following the review of the decision-making tools, the ST approach demonstrates criticality in addressing complex and unstructured problems. ST overcomes the constraints of unstructured problems based on its inclusive and participatory approach by incorporating different types of data, diverse stakeholders and multiple perspectives into decisions making. It allows the fostering of knowledge by building consensus across entrenched disciplinary boundaries represented by a broad range of stakeholders. ST offers the potential to explore, understand and manage activities in MAR which is characterised by paucity and or scattered data, multiple interaction, conflicting interest, and complexity. Since a system is conceived, it is therefore important to discuss cognitive tools that draw upon insights into interdisciplinary systems problems using non-computational though conceptual methods such as mental models to generate knowledge.

5.2 Mental model: An important conceptualising tool in systems thinking

Mental models are considered cognitive structures constructed by individuals based on their lived experiences (Jones et al., 2011) and are conceived as internal representations of external reality. They form the basis of reasoning and decision making. Environmental problems are driven by human decision, therefore, to understand human-environmental interaction, it is important to explore the mental models of individuals with a stake on the issue so as to understand how human management of environmental systems interact. Each stakeholder has a mental model of a problematic issue and with plurality of stakeholders with interest in a problem, it is important to understand how this differ between different stakeholder individuals or groups and how it can be exploited to have a holistic understanding of a problem of interest through consensus building and mental model convergence. According to (Jones et al., 2014) an individual's mental models is limited and context-dependent, they however, are important in understanding complex and dynamic systems. It creates a systemic structure that is observer-dependent and requires multiple perspectives with the aim of treating issues as a goal to be achieved and not a problem to be solved. Since we cannot see how people think, we therefore rely on methods to elicit their mental models as a step toward problem appraisal and evidence gathering. According to Cabrera, systems thinking aims at solving complex problems by conceptualising unstructured problems and developing conceptual models and frameworks whilst taking desirable holistic actions to improve systems conditions (Cabrera et al. 2008). By changing the way, we conceptualise, we change/adjust our thinking. In this study, it is recognised that both industrial and natural ecosystems interact to produce complex environmental problems that requires integrative and interdisciplinary mechanism to deal with. Mental models are critical in human perception and conception and they offer cues on human-environment interactions. They are unique to individuals and considered incomplete because they are subjective and context-dependent and because of its dynamic process, there are limitations in conceptualising complex issues (Jones et al., 2011). They represent a conceptual system according to Johnson-Laird (1983) and could represent both short and long term knowledge. It is an important tool that allows for similarities and differences to be explored; create collective representation and support the process of social learning that overcomes the limitation of individual 'stakeholder' thinking. According to Jones and colleagues, they are practical and useful rather than accurate representation of reality (Jones et al., 2014). People find it difficult to retain feedback processes associated with an unstructured problem conceptualisation whilst more mentally disposed to adopting an event-based type of mental model. However, this can be overcome by recreating historical event in a scenario-based approach and representing them as a network of concepts and relations. Such can be achieved during group model building process or other mediated participatory research approaches.

It is noteworthy that in pursuit of actions that will ensure the sustainability of MARs, inclusive views, stakeholder participation and collaboration is key.

5.3 Participation and stakeholder engagement

A participatory approach aims at producing informed and consensus knowledge and the process creates a robust civic capacity, trust, and legitimacy (Beierle & Cayford, 2002). Consequently, as outcome of the deliberative process, stakeholders are empowered with knowledge of how to deal with the complex environmental and sustainability problems. The participatory approach empowers local stakeholders by fostering insight and learning by improving communication and exchange of viewpoints and therefore a veritable approach in exploratory studies aimed at tackling messy problems.

Stakeholder involvement is critical in decision-making since it creates opportunity for profound understanding of the subject of discourse (Bryson, 2004; Nutt, 1990) while a single perspective to problem conceptualisation can be reductionist and often leads to bad decisions (Nutt, 1990). Stakeholders are important in interdisciplinary study because of the different perspectives they provide in dealing with complex socio-ecological problems. It is therefore necessary to identify stakeholders in MARs in order to understand how extractive activities in such regions could occasion temporal and spatial problems in different sectors and for different interest groups. Generally, and in line with sustainability principles, environment, social and economic factors underpin stakeholders' interest. This tripartite view is the basic underpinning of the concept of sustainability (Azapagic & Perdan, 2000; Adisa Azapagic, 2004; Labuschagne, Brent, & Van Erck, 2005; Singh et al., 2009). Adaptation of the systems approach is therefore based on a sustainability model of which this research explores the opportunity for systems to deliver a management framework for a sustainable mineral active region. The sustainability construct according to (Azapagic & Perdan, 2000) is based on meeting environmental, economic and social goals. Table 5.1 presents key stakeholders in a mineral active region and their interests.

Table 5.1 Stakeholder and their primary interest in sustainability (Azapagic 2004)

Stakeholder	Economic	Environmental	Social
Employees	⊕	+	⊕
Trade unions	⊕	-	⊕
Contractors	⊕	+	+
Suppliers	⊕	-	-
Customers	⊕	+	+
Shareholders	⊕	+	+
Creditors	⊕	+	+
Insurers	⊕	⊕	⊕
Local communities	⊕	⊕	⊕
Local authorities	⊕	⊕	⊕
Government	⊕	⊕	⊕
NGOs	+	⊕	⊕

⊕ strong interest + some interest – no interest

Stakeholders provide perspectives for understanding of interactions and to enable discourse on vital issues that ordinarily are not considered in policy decisions. Acknowledging that people's perception and understanding of things vary whilst describing the same problem validates the need for stakeholder participation to enable consensus through shared knowledge (Magner, 2011). Although the stakeholder approach to management has been widely advocated in literature, Reed (2009) argues that it is by recognising who really has stake in a project/problem and identifying their concern can the approach be exploited. Discourse on stakeholder participation has gained increased recognition (Achterkamp & Vos, 2007), because participatory processes have the potential of stimulating social learning and influence decision (Tuinstra et al., 2008). Improvements in analysis of complex environmental and sustainability issues could be achieved through participatory modelling approaches that can promote synergy in learning and consequently support decision-making and implementation (Antunes et al., 2006). Bryson (2004) proposed stakeholder identification analysis techniques and suggested that this involves the process of "organising participation, generating ideas for strategic intervention, problem formulation and solution search, building a winning coalition for proposal development, review, and adoption; and implementing, monitoring, and evaluating strategic interventions". Applying the stakeholders' concept is a strategy to help define the boundaries of a MAR with regards to spatial and temporal scales so as to understand who is involved and who is affected. A stakeholder in this context is any person or group that is affected or that affects the activities in a MAR. That is, they influence or could be influenced by the interaction occurring in a MAR. It is worth noting that stakeholders are not limited by geographical boundaries.

The participatory approach to environmental policy making has been advocated as an approach that can bridge the gap between policy, society, and practice. This was bolstered by the 1992 [2]Rio declaration on environment and development as enshrined in Principle 10 of the declaration. Van Den Hove (2000) supports the argument for a participatory approach in environmental policy making because of the uncertainties and insufficient knowledge in environmental issues; imperfect scientific knowledge as well as the extended spatial-temporal scales of causes and effects of environmental processes. According to Videira et al. (2003), the paradigm for sound environmental decision-making in contemporary societies is shifting towards favouring public and stakeholder participation. Mingers and Rosenhead, (2004) posit that problem-structuring methods that are participatory will enable understanding of the root cause of problems. The participatory process entails gathering historical and contemporary views on the problem of discourse by creating a collective representation and integration of different perspectives so as to improve overall understanding of the system based on collaboration and stakeholder inputs. That means that the suitable metric for assessment would be the legitimate perspectives and world views of stakeholders. The participatory process takes into consideration the hard (biophysical) and the soft interactions in a system. Videira et al. (2010) suggests that the process of participatory modelling (group model building or mediated modelling) starts with

[2] Principle 10 of the 1992 Rio Declaration on Environment and Development. "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided".

definition of problem and conceptualization of the patterns that underlie the trends that characterise a persistent problem. This approach is consistent with Checkland's soft systems methodology (SSM) which is rooted on shared problem and vision by actors resulting in learning and consequent collective action aimed at improving the system (Checkland, 1981). The process provides a mechanism for participating stakeholders to have broader understanding of the problem by allowing for divergent views since it is difficult for a single stakeholder to have an overall understanding of the system because of cognitive limitations and human bias. The process allows for scoping and eliciting the mental models of stakeholders to identify key issues and variables whilst focusing on promoting learning and improving systems understanding. This is in line with the position of (Videira et al., 2003) who affirms that leveraging the participatory model to scope out interaction between ecological, economic and social subsystem is useful in identifying forces that drive environmental pressure.

5.4 Data types and collection

The review of literature conducted in this research demonstrates that a suitable approach to achieving the research aim was through systems thinking which can be realised through a participatory approach. A framework which is based on a participatory approach will be the basis of the research methodology as well as the delivery mechanism. The research discourse affects different sectors and different interest groups and, in my assessment, would require a thoughtful understanding of the varying interest of different groups who have a stake in the problem. The benefits of the participatory approach in relation to environmental policy making has been widely acknowledged, see (Cedex, 2000; Mingers & Rosenhead, 2004; Van Den Hove, 2000; Videira et al., 2003). After an extensive study in the ND region of Nigeria, Adekola et al (2015) underscored the need to develop managing institutions in which all stakeholders including the local people are integrated in a participatory decision making which is a critical approach that will ensure sustainable management of activities in mineral active regions like the Niger delta. The need for a participatory research approach was also buttressed as part of the conclusion of the study funded by World Bank "defining an environmental development strategy for the Niger delta" (World Bank, 1995). Therefore, this research was designed to be addressed through a participatory framework that allows for multidisciplinary data to be collected and explored. The multidisciplinary paradigm is important in the problem structuring process by identifying problems or issues of concern to management and main stakeholders, collection of preliminary information and conduct of group sessions. In addressing the data requirement, different categories of data including information generated through a group model building (GMB) workshop, quantitative data (oil spill and gas flare data) was acquired and explored. The GMB workshop involves the elicitation of mental models (cognitive constructions) of stakeholders/participants for the purpose of understanding the problem and key drivers of change and mentally simulate scenarios of the current state and the ideal conditions of the region and measures to achieve the desirable ideal state through a policy response driven by consensus. Interviews were conducted; however, it is noteworthy that the decision to conduct interviews was not part of the original research design but was made to improve the overall quality of the research. Details of the interview is found in step 6 of the application of the framework (section 7.5: the participatory process). A reconnaissance visit was conducted which provided an opportunity to document informal experiences and sociocultural perspective of individuals, communities, and ecosystems.

5.5 Discussion

In this chapter, the research design, methodology and the overall research strategy was examined in order to understand the appropriate method to be used in the research. Because the study was aimed toward policy making and management of MARs, several decision-making tools employed in environmental research including, Systems Thinking, Stakeholder Analysis, Drivers–Pressure–State–Impact–Response and Multi-Criteria Decision Analysis were reviewed to select a method and procedure that is suitable to address the research and answer the research questions. System thinking was selected based on its holistic approach and criticality in addressing complex and unstructured problems. The systems thinking in the research relies on the participatory approach which is a robust approach to engage stakeholders and elicit their mental models with a view to changing entrenched disciplinary and mechanistic world view of stakeholder to a more holistic worldview that is interactive and interdependent. Ison et al. (1997) mention that problems are social constructions based on diverse perspectives which do not exist in isolation but rather related to other problems in a network. He furthered his opinion saying that participatory approach could engender improvements that are sustainable but emphasised that the interventions should neither be mechanistic nor deterministic. A given problem does not occur in isolation. It is socially constructed on the basis of different perspectives and is part of an interrelated network of problems. This position underscores the importance of thinking and communication amongst stakeholders, data collection, learning and conceptual modelling of relevant subsystems. The essence is to understand where we are (current systems state) and where we want to be (ideal and sustainable systems state). The learning process of systems approach seek to ensure inclusiveness through collective democratic representation of multiple perspectives. It is noteworthy that environmental problems are intrinsically complex and mostly a consequence of past actions and involve multiple actors with diverse interest. Conventional top-down, command and control approaches are ineffective and not adaptive in addressing these problems. A participatory systems process allows different viewpoints to engage and collectively explore the real-world problems through a structured debate as advocated by (Checkland, 1989) and (Senge, 1990). A participatory systems approach is suitable for understanding the complex environment-socio-economic problems that characterise MARs.

In conclusion, the methodology for this research has been clearly highlighted and the reason for the choice was because of the complex nature of MARs including several policy resistant scenarios and unsustainable trends observed in many of these regions. To facilitate the management of MAR, I sought to develop a framework that is based on systems approach though stakeholder’s participation.

Chapter 6

6 The Framework

A framework has been put together to demonstrate how the systems tools selected can be applied to support policy making and management of MARs. In this chapter, we highlight the different steps in the framework. The rationale for the participatory framework is underpinned by many scholarly and institutional research findings which supports the call for participatory methodologies. Following the Rio Declaration on Environment and Development which bolstered the call for and ushered the participatory principle, many policy-making institutions and government have embraced the principle and have sought to promote the regime, for example the (European Environment Agency, 2011). Van Den Hove (2000) offers an interpretation that the increasing call for participatory approaches in environmental decision making is to ensure the sustainability of environmental resources which is underpinned by ecological, social and economic context and characterised by complexity, uncertainty and non-linear dynamics. Videira et al. (2005) advocates for strong participatory processes which supports integration and co-production of knowledge, consensus-building, transparency, conflict resolution and management of indeterminacy in scientific outcomes. The premise is that participatory approach should base on democratic participation. This assertion is predicated on Gundersen (1995) argument that democratic deliberation of environmental problems is a rational approach that will promote citizen active participation and enhance environmental rationality through a collective, holistic and long-term thinking. The overarching objective is to ensure the sustainability of environmental resources through collective participation and consensus. Figure 6.1 is a pyramidal representation of the participatory approach to sustainability adapted from Meadows (1998) and modified by Videira and colleagues (2005).

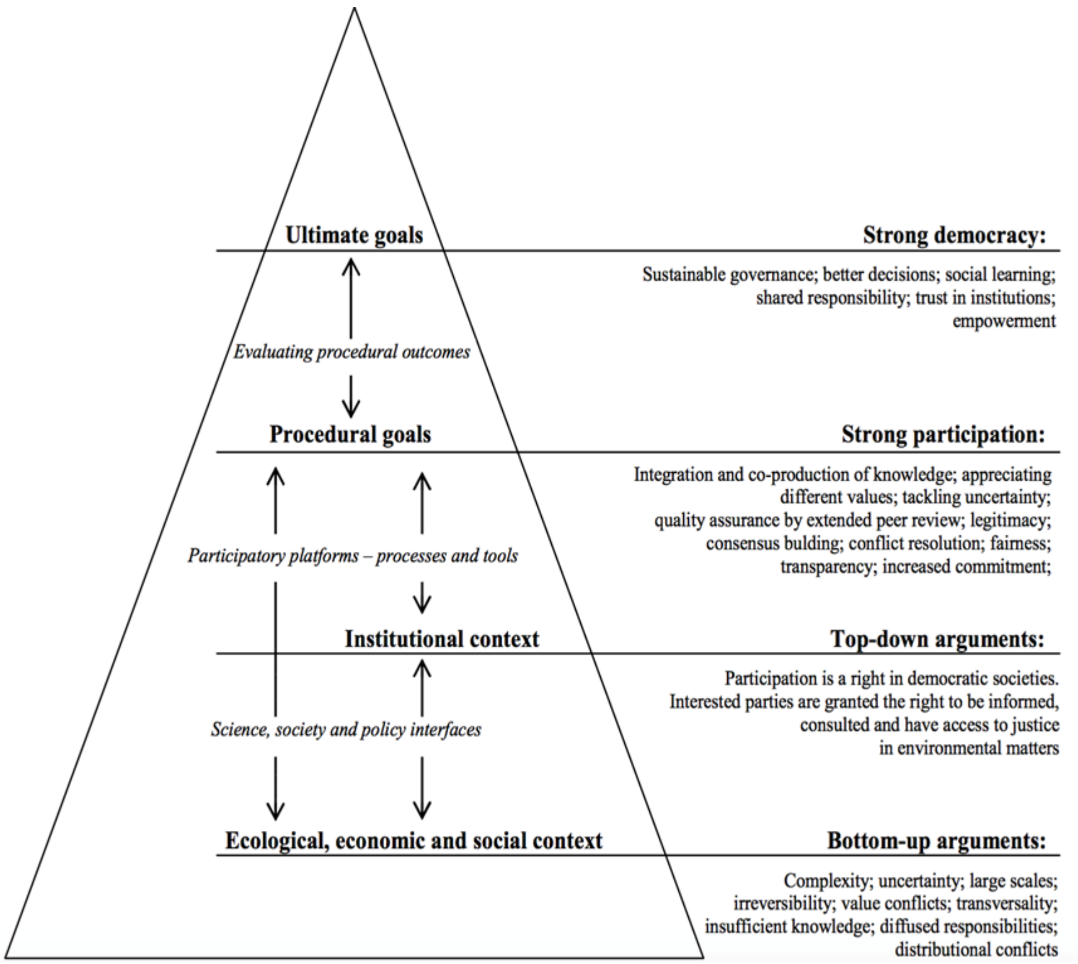

Figure 6-1 Strong Participatory Approach To Sustainability. Source: (Videira et al. 2005 as Adapted from Meadows (1998).

In the section, the steps for the framework, a process consisting of 8 steps was developed to support the management of mineral active regions.

6.1 Define the Region on the Basis of MAR Characteristics

The legacy of mineral extraction in many regions affirms the need to understand the double-edged effect of extractive activities on both the economy and environment. Not all regions with deposits of natural mineral resources (subsoil resources) qualify as MAR, however, in this study, building on the work of (Doloreux et al., 2008; Franks et al., 2013; Young & Matthews, 2007) we bring definitional clarity to the research context. "Mineral Active Regions are considered in this study as those with stocks of geological resources of intrinsic economic interest that can be used beyond the scope and or need of the local people and as a result, have undergone decades of extraction. These regions have commercially extractable deposits of minerals or energy resources with historical production, proven reserves, and on-going extractive activities". Literature review and extensive evaluation of many resource regions was considered before structuring the definition. Although literature review is limited in rigour, and less systematic, it was useful in fact finding which was the essence of using it in this research. Therefore, for the framework to be applied to a region to support either policy making or management, it should qualify as a MAR in the context of the aforestated definition.

6.2 Define the Systems Components, Boundaries, and Scale

Extractive processes broadly have primary and secondary impacts which differs in scale, scope, and boundaries. It is important to discuss the scale in the research context as a rudimentary step toward understanding the magnitude of the problem and to find appropriate course of action to take towards solution finding. The issue of scale has social, ecological, and political implications. Defining the scale and spatial delimitation of an environmental problem is an unavoidable step towards management and solution finding. Specifying the components and boundaries of a system can be difficult due to interactions across spatial and temporal scales (Manson, 2001). For example, minerals are subject to market forces that are inherently transboundary including the environmental impacts arising from their extraction. Setting boundaries is a hallmark step towards building an effective system assessment (Cabrera & Colosi 2008) and therefore helps to give a good picture of the extent of the problem focus. However, viewing problems from a systems thinking perspective erases the entrenched disciplinary boundaries and allows for a holistic appreciation of events, patterns and structures with a degree of freedom as to understand complexity (Hjorth & Bagheri, 2006). Boundaries are both extensive and intensive; an extensive boundary is the scope or breadth of what is included in the model while an intensive boundary considers the level of detail or depth of elements or variables included in the system model represented. For a MAR, environmental, economic, social, and institutional variables are the relevant subsystems (extensive boundaries) whilst ecosystem health, intergenerational effects, socio-cultural values, and institutional capacity and others are examples of the intensive boundaries of the mineral active region systems. Figure 6.2 is a conceptual presentation of the extensive and intensive dimensions of the systems boundary construct.

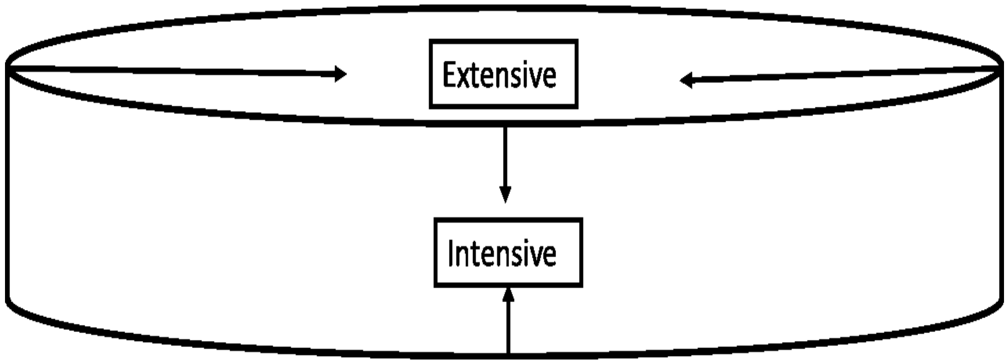

Figure 6-2 A Pictorial Representation of the Extensive And Intensive Dimensions of the Systems Boundary Construct. Source: The systems thinker, 1997.

6.2.1 Systems Purpose and Function of a MAR

As previously defined, MAR as a system exist to ensure provision of natural resources, ecosystem services and associated economic provisions through their extraction whilst maintaining the structure, functioning, productivity, and diversity of the host regions' ecosystem. The stocks of resource in a mineral active region holds the key to unlocking its economic potential. Mineral and energy resources are mostly discovered in remote regions with delicate ecosystems that provide several ecosystems services. This brings about a competing interest between active subsoil mineral extraction and other services from host ecosystems. From a broad perspective, subsoil resources exist to deliver socio-economic benefits to trustees of mineral resources whilst biodiversity provides ecological resource and ecosystems services generally to host communities who most of the times are not trustees of mineral resource wealth of their land. Therefore, the function of the system can be viewed differently depending on the stakeholder involved. However, studies have revealed that benefits and costs generated from mineral extraction affect stakeholders differently.

6.3 Examine the Resource Governance Regime

The exploitation of natural resources shapes the political realities of host countries and regions. The process acquires a political dimension, with strong connection to its economy, ecosystem, including local communities who directly or indirectly are affected by the process of natural resource development. Governance regimes have evolved to manage activities surrounding natural resource development including associated 'externalities. The governance regimes rely on economic/socio-political instruments to deliver environmental and natural resource interventions. Fiscal regimes or economic instruments rely on trade, subsidies, markets, taxes while the socio-political relies on governance, institutional and legal framework. The political aspect deals with jurisdictional level of regulation (regional, national, international) through the application of relevant domestic legislation, international treaties, and conventions. It is important to highlight the political as well as the scalar architecture of governance structures in addressing environmental and resource problems. The political context of scale encompasses actors and their perception, and planes of political and economic organisation (Herbert et al., 2013). It is worth noting that problems associated with mineral active regions and natural resource systems involves many trade-offs whilst management is limited in space, time and by agency mandates. Although management actions are usually local, it should be broad and holistic in order to recognise consequence in larger ecosystems and their survival. This can be achieved by embedding of local interest and management objectives in the perspective of global change and standards.

6.4 Identify Actors and Relevant Stakeholders

Generally, presence of exploitable mineral resources attracts different players and diverse interest amongst others; international and local investors, national governments and its agencies, and local communities (Kaup, 2008; Rodela, 2012). These group are referred to here as stakeholders. Such configuration of diverse interests and interactions amongst stakeholder can be complex and often problematic. The complexity emerges most times due to conflict of interest among different stakeholders. Stakeholders are critical in interdisciplinary research/study involving complex socio-ecological problems with the objective to achieve sustainability because of the different perspectives they provide in dealing with complex problems. They generally fall within three categories: dependent (who lives on the services provided by the regions ecosystem), influent (whose interest lie on the resources of the region), and managerial (those who have responsibility for its management). However, it is by being aware who really has a stake in a project/problem and identifying their interest/concern can the approach be exploited (Reed et al., 2009). Stakeholder identification and selection should be democratic in order to have the appropriate set of stakeholders in a project. However, the overarching objective should be to identify and involve the most relevant stakeholders to optimise participatory activities. An approach to achieving this is through the hydra approach (Sanò et al., 2010) in which the problem owner or most relevant stakeholder identifies the major stakeholder and who in turn identify other stakeholders in a snowball technique

6.5 Engage Stakeholders in a Participatory Group Model Building Process

This is a learning and elicitation process that provides opportunity for knowledge and information exchange Van Den Hove (2000) which aims to address issues like uncertainty arising from knowledge gap—and characterise environmental problems. It requires a facilitator and involves participants to conceptualise the real-world problem and to have a representative image or a vision of a desired state of the systems as well as what could be done to achieve the desired state. The participants collectively explore the problem and the problem drivers in a participatory format. Group model-building or group modelling workshop (GMB) is one of the participatory process that can be leveraged. It aims at tackling unstructured problems through group process structuring, communication, consensus and commitment amongst stakeholders (Videira et al., 2010). The GMB is a participatory systems strategy which is part of the engagement process in the framework. The skills required here include communication skills, conflict handling skills, consensus and commitment building skills.

6.6 Outcome Of The Participatory Process

The outcome of the participatory process is achieved through the elicitation of variables, identification of convergent variables and feedbacks in the systems. Consensus can be achieved through voting or other democratic processes that may be agreed upon by the participants. Causal loop diagrams can be developed from a cluster of variables identified. The process can lead to a better understanding of the problem by revealing hidden interactions in the system and consequently lead to policy recommendation.

6.7 Validation Through Statistical or Empirical Approaches

Observed problems and consensus reached by participants can be subjective and liable to bias and may not be accepted as scientific for policy recommendation or to support management. Therefore, the validation of the outcome of the participatory process through empirical approaches that describe real-time events is useful to researchers/managers/policy makers to develop better understanding and to draw relevant conclusions.

6.8 Developing the MAR Framework

To develop a framework that facilitates the management of MARs, we aspired to develop a tool that can bridge the transformational process of the region (our system) moving from its current unsustainable state to a desired sustainable state (a vision for a desired future outcome). This is done in collaboration with relevant stakeholders. Since a system is a product of its interaction, to define the "current state" and "desired state" of the MAR, the interactions among the components of the system and actions needed to change undesirable interaction is the focus. For every MAR, there is an initial (default) state of interaction between physical, ecological, human, social, technical, political components that make them complex and difficult to manage. These interactions are heterogeneous and are characterised by multiple agents and their conflicting interest. The emergent outcome of these interactions could be sustainable or unsustainable depending on the configuration of the interactions. Extractive activities affect individuals and groups differently. It brings benefits to some and limitations to others. When extractive processes result in environmental degradation, exclusion, distributive inequity, inequality, corruption, unemployment, and loss of livelihood, it is unsustainable. This research was intended to find an approach to improve the management of MARs and ensure their sustainability with reference to regional communities and ecological sustainability. Therefore, bearing in mind that sustainability could mean different things for different stakeholders, the desired state of the system is defined with reference to the sustainable development goals.

It is worth noting that complexity and uncertainty complicate environmental and natural resource systems and results in surprises, policy resistance and hinder sustainable development whilst study shows that attempts to try to understand these problems and manage them have relied on traditional management approaches. Traditional management approaches have been ineffective because of their failure to address these confounding issues by attempting to simplify complexity through discrete interventions, such as trying to address poverty, social problems without addressing environmental degradation which is a primary cause of poverty in these regions. These issues do not exist in isolation, therefore, requires a holistic approach. The activities associated with resource extraction are multi-dimensional and multi-stakeholder in attribute, the problems are characteristically complex and unstructured and therefore requires a systemic intervention through the application of systems tools.

The term ‘tool’, in Sexton’s view (Sexton, 1998) are procedures that support decision-makers, whereas Petihakis et al. (2011) consider them as enabling instruments for knowledge exchange. Systems tools is applied here as a holistic tool and serves as both a decision-support and a tool for knowledge exchange. The philosophy of the approach justifies its potential and criticality in addressing complex MAR problems because it overcomes the constraints of traditional management and allows for inclusion of variables/components that are not usually considered by constructing mental models that are broad. Based on the conceptual model for a MAR developed earlier in this study which represents a system view of a mineral active region and the review of systems thinking tools undertaken, a decision-support framework for the management of MAR is proposed here. Although the conceptual model represents the systems view of a MAR that shows the relationship between the systems components, it does not describe the dynamics of the interactions that exist but enables retention of the complex picture that might be lost when parts or fragments of a system or sub-systems are put together to form a complex picture. The figure 6.3 is the conceptual model earlier developed in the process that represents a system view of the components of a MAR while figure 6.4 is a preliminary generic conceptual model of the ecosystem interactions.

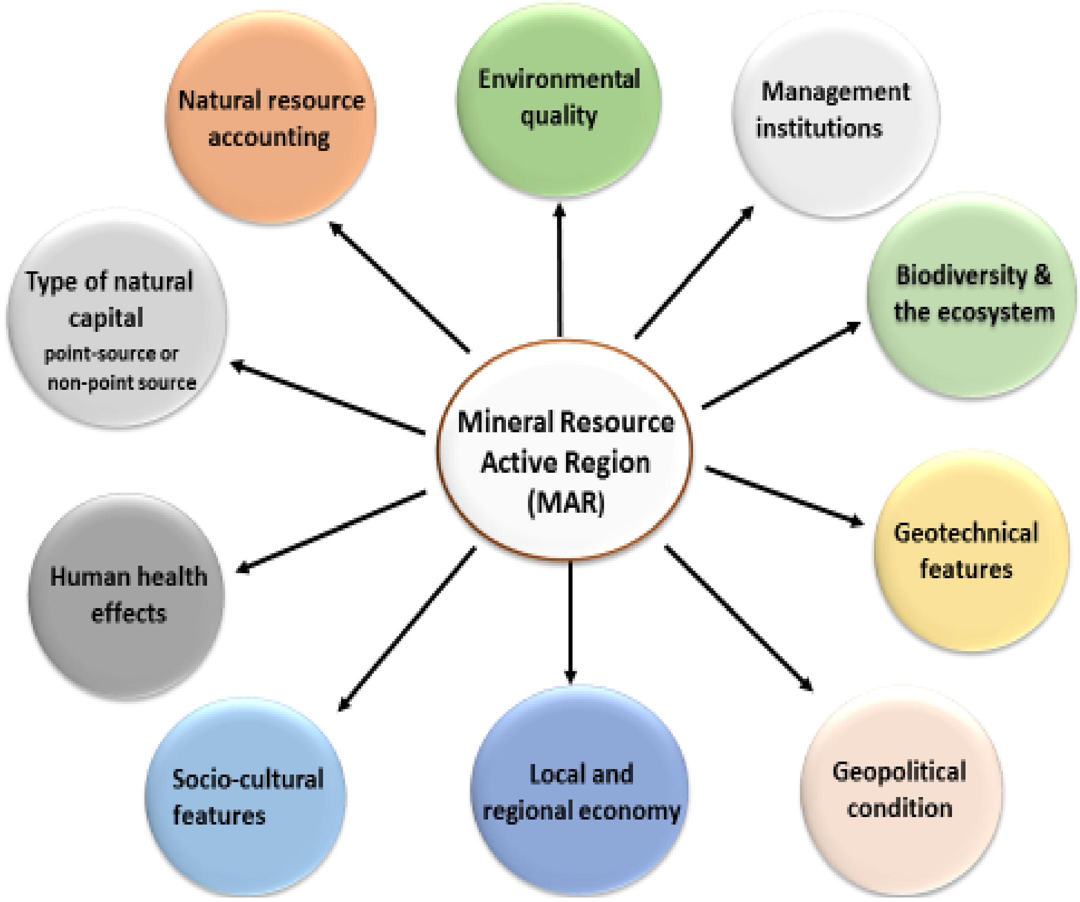

Figure 6-3 The conceptual systems representation of the components

The conceptual models serve as a comprehensive template to enhance the understanding of stakeholders and demonstrate that different sectors and components/variables are interacting and explains the need for a cross-sectoral, interdisciplinary diagnostic tool. The conceptual models are oriented towards understanding of the system based on its multi-dimensional and multi-stakeholder characteristics and forms part of the problem structuring in a decision-making process.

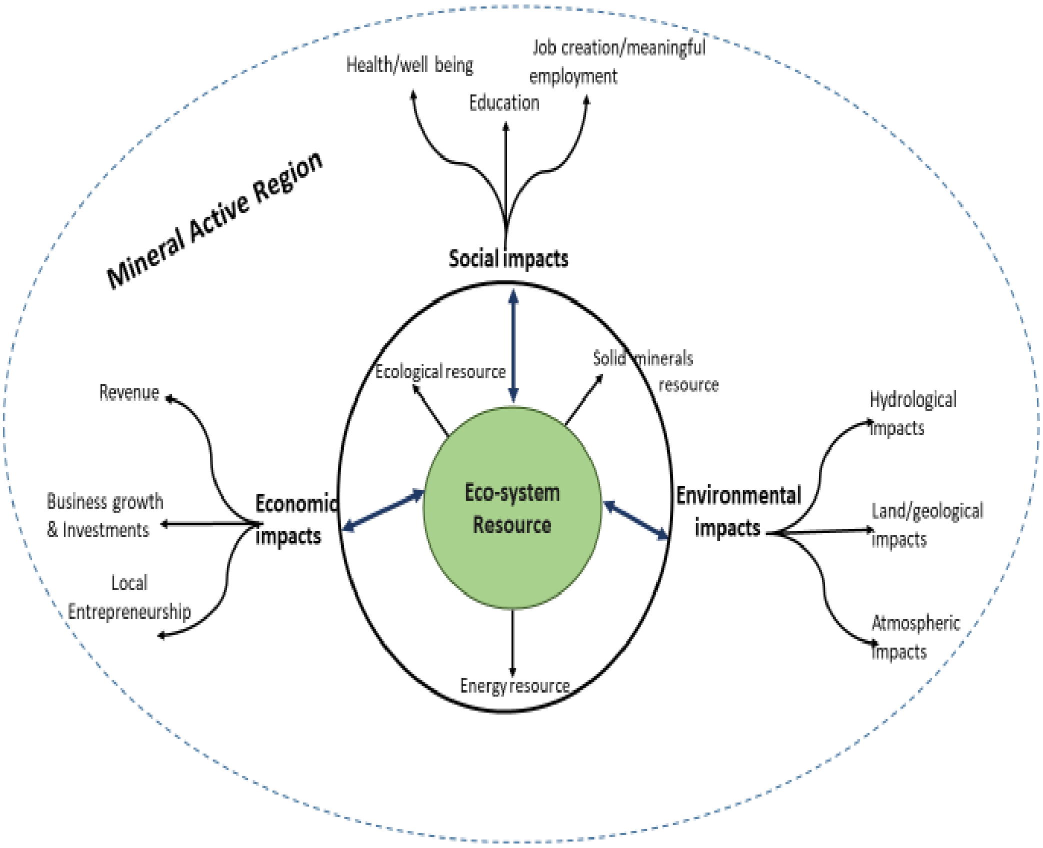

Figure 6-4 A preliminary generic conceptual model of the ecosystem interactions

Decision-making process according to Belton and colleague involves a three stage process: problem structuring, problem analysis and problem resolution (Belton & Stewart, 2002). The participation of stakeholders through a group model building is a dialogue process that is designed to let participants reflect the group's own concepts of its problem in its systemic context and create shared understanding that leads to solution finding. It is a deliberative platform to engage the complex problem surrounding the management and sustainability of MARs. In this, we acknowledge there are value conflicts, as well as consequences and buttresses the need for stakeholder engagement. Having highlighted the steps in the framework, here, a framework that will assemble the different pieces of knowledge developed in the process in a practicable way to serve as a learning, interactive, and decision-making tool is presented here.

Figure 6.5 is the flow chart for the participatory framework while Figure 6.6 illustrates the participatory systems process showing the process of moving from the current state to the desired state via the participation of stakeholders.

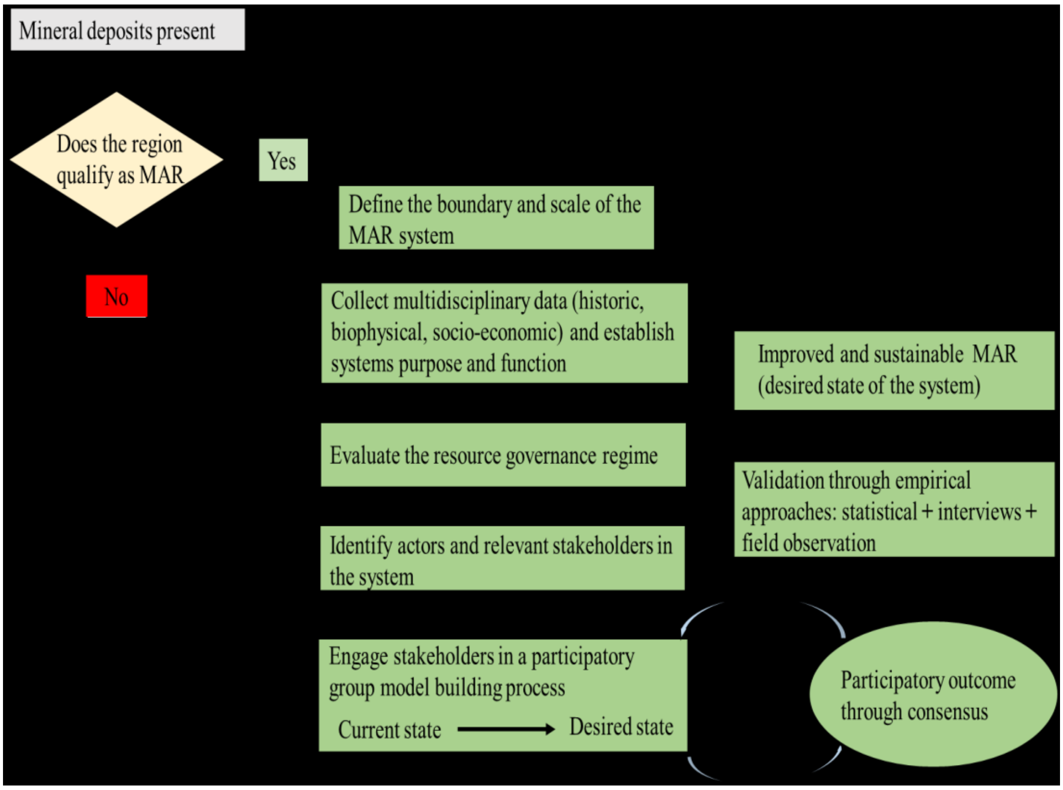

Figure 6-5 Flow chart of the systems framework

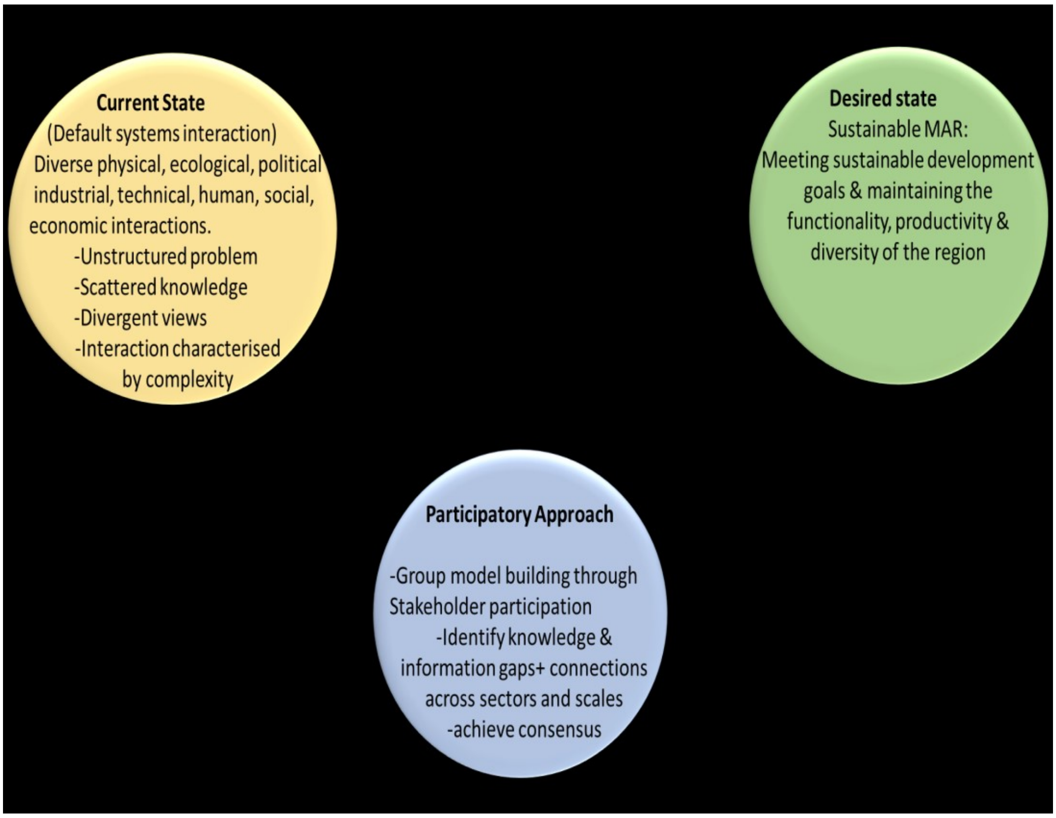

Figure 6-6 A systems framework for management of mineral active regions (MAR)

This is how to guide a step by step approach to applying the framework. It is designed as a structural guideline to demonstrate how the process should be accomplished and allows for context specific details because of its generic functionality. It will be reviewed and updated as lessons are learned from application in other MARs.

6.9 Steps to Guide the Use of the Framework

I. The region of interest should be evaluated to ensure it qualifies as a MAR.

II. Establish the boundaries and spatially delimit the system being investigated: This is a hallmark step in organising and developing an effective system.

III. Collect multidisciplinary data and define the purpose of the system: A system is defined to understand its purpose. Generally, a system can be multifunctional when it performs different functions and serves different stakeholders' needs. To understand the system, multidisciplinary data/information is collected. The multidisciplinary considers the following: Historic, biophysical, and socio-economic data are collected for problem structuring purpose considering that the problems of these regions are usually unstructured, and views are divergent. Biophysical analysed (e.g. geology, emissions release, pollution, water quality, land use and vegetation changes, effluents, dusts, tailings, and leachate etc) to show behaviour-over time of effects of extractive processes in the system. Historic data to understand the cultural system, traditional economy and local ecosystems are collected.

IV. Evaluate the resource governance regime in place to manage activities in the region. National laws, policies and multilateral environmental conventions that have direct and indirect significance in mineral extraction is appraised to understand measures of progress, weaknesses and how they impact management of the system.

V. Identification of stakeholders: Activities in MARs involve different stakeholder groups and multiple actors with different interest which are often conflicting. Need therefore arises for a transdisciplinary and holistic approach to build up knowledge and understand the interests and motivations of actors in the system. Stakeholders are identified as a step toward the participatory process. The stakeholders can be categorised as dependent, influent, and managerial. Stakeholders are part of the system although they may not be in a geographic proximity with region.

VI. The participatory process: Group model building is a participatory process that rely on mental models. We argue that by improving stakeholder's mental model we could engender behavioural change through a change of attitude. The process fosters learning because the process of variable elicitation allows knowledge exchange and shared vision of the problem. It allows information gaps to be identified, and connections across the different components of the system to be made and to reach consensus amongst participating stakeholders on issues that are conflicting and actions to be taken to improve the system. It exposes conflicts and resolve them through consensus and helps to deconstruct disciplinary view of a problem (change their mental models and gain more insights of the problem).

VII. Participants legitimate views become adopted as the metric of assessment and consensus which can be achieved by simple agreement or a voting process.

VIII. Validation of the outcome of the participatory process through empirical approaches. This could be through analytical, statistical or laboratory findings.

6.10 Sustainable Development Goals and the Case of the ND-MAR

This study aimed to develop a framework to support policy making and improve the management of MARs in order to ensure their sustainability. Sustainable development remains unfulfilled and the future of the region is threatened by deteriorating economic and environmental conditions that are not being addressed by present policies and actions. It underscores the need to understand how environmental and natural resource problems intersect and/or overlap with environmental policies that cut across mineral and energy extraction, energy policy, local economy, health, social, and ecosystem integrity. From the foregoing, research demonstrates an unsustainable pattern of resource management and stresses the need for a management approach that can deliver significant change that benefits all stakeholders while delivering regional and community aspirations. Therefore, we present sustainable development goals that are affected by extractive activities in the region with the intention of demonstrating that mineral extraction has a systemic impact on the sustainability of communities and ecosystems.

Table 6.1 Some of the Sustainable Development Goals affected by Activities in the Region

	Despite decades of oil and gas extraction in the Niger Delta, poverty is prevalent in the region. This has been made worse by the degradation of the ecosystems that provides ecosystem good and services. This has been empirically associated with oil prospecting and production. For example, the mangroves which is predominant in the region performs regulatory, provisioning, cultural and supporting services. The provisioning service is the economic mainstay of many of the communities. The Niger Delta has an environmental linked economy. To end poverty the region's environment must be preserved through responsible extractive operations and stewardship responsibility.
	Increased health burden has been demonstrated in the region. Several health issues identified are externalities of extractive processes. Decades of oil spillages, leaks, flaring, venting is a public health concern as critical thresholds are being exceeded. To achieve sustainable development in the region, health and wellbeing of communities must be protected by protecting the environment whilst making healthcare accessible and affordable to the people.
	Communities rely on River/Creeks as source of water while plastic sachets water bought from towns serves as a source of drinking water of acceptable quality. Many of the communities hosting oil and gas assets have not benefited from oil wealth but bear the environmental and socio-economic cost of extractive processes. Open faecal disposal is predominant in communities. Access to clean water in the form of "pipe borne water", sanitation and adequate sewage disposal facilities must be provided.
	Many communities in the region use biomass as their energy source because of unavailability or unaffordability and access to electricity and refined products. Some resort to 'bunkering' and interdiction of oil pipelines to provide for fuels. To ensure the sustainability of communities and ecosystems, clean and affordable source of energy must be available and affordable.

10 REDUCED INEQUALITIES	Extractive activities in the region have created inequality between the 'haves' and 'haves not'. To ensure a sustainable region, effort must be made to reduce economic inequalities through robust fiscal regime, patronage to local products, employment, and maintenance of a healthy environment since the economy of indigenous communities in the region is environment dependent.
13 CLIMATE ACTION	Extractive and refinery activities in the region continues to release greenhouse gases which adds to the global climate budget with serious microclimatic effects in the region. Zero gas flare should be aimed through incentivisation and enforcement of activities such as gas flaring and venting that are damaging to the climate.
14 LIFE BELOW WATER	The ND region has the largest wet land in Africa and third largest in the world. For example, mangrove forests are vital for healthy coastal ecosystem. It is being threatened by multiple activities including acidification, aquaculture, oil spill. Studies show massive decline in aquatic species such as fish and this has been associated with extractive activities in the region. Environmental and economic pressure should be addressed to combat the adverse effects that threaten biodiversity and livelihood of millions of people who depend on marine and coastal resources.
15 LIFE ON LAND	Observed in the region is the destruction of biodiversity due to oil and gas extraction and associated activities with negative implications on the ecosystem's services. Erosion, unsustainable agricultural practices damage soil fertility and threaten the sustainability of the region. To ensure the sustainability of life on land, terrestrial ecosystems must be protected.
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Institutions tasked with the management of activities in the region has struggled with corruption, bureaucracy, multiplicity of functions and overlapping jurisdictional responsibilities. To restore the faith of people and communities, institutions need to be transparent and accountable.

6.11 Discussion

Based on the investigation earlier conducted about mineral active regions to understand why they are problematic and difficult to manage, evaluation of different methodologies to manage such complex systems was conducted which resulted in the selection of systems thinking. To facilitate policy making and support management of

MARs, we sought to develop a participatory system framework which integrates information from different disciplinary domains to solve socially relevant complex problems. The framework proposed here is an outcome of the review of MARs and appraisal of different decision-making approaches to create a tool that is inclusive and support the understanding and management of complex natural resource systems as observed in MARs. The proposed framework recognises two systems states. The current state and the envisioned desired state. Therefore, the task lies on actions and steps that can be taken to reach the desired state. The flowchart of the systems framework gives a how to guide a step by step approach to applying the framework and the process is achieved through a participatory approach which potentially result in knowledge sharing and exchange of viewpoints among stakeholders which can result in knowledge development, consensus and commitment to action that can ensure a desired system change. The goal was to integrate scattered knowledge with a view to developing shared knowledge and mould consensus as a means for guiding actions to achieve a state where, through a transparent and accountable governance regime, mineral development can be pursued to ensure sustainable development (communities and ecosystems). For example, (Stadler, 2002) argues that knowledge integration is fundamental in managing and coping with complex problems. Although policy making is a complex process, the creativity, flexibility, inclusivity, stakeholder driven approach underpinned by the framework is a departure from the traditional approaches characterised by either economic rationality, top-down, technical, and expert knowledge modus operandi.

The complexity in resource and environmental problems requires the involvement of interest groups in the problem definition and solution finding through communication and mediation in a guided approach which the framework provides. It is expected that through better understanding of the interaction in the systems and by empowering stakeholders to understand the consequences of their actions and interactions in the system, the process leads to behaviour change and systems informed management that consequently results in systems improvement and a sustainable MAR.

The framework is not a deterministic tool but a tool that has the potential to deliver sustainable outcomes because of its participatory approach and broad stakeholder perspective. It is not a new scientific model but a novel practical tool for enabling interaction by gathering information and viewpoints relevant in decision making.

The application of the framework to a case study was demonstrated in the next chapter (7) of this thesis and starts with the collection catchment information of the case study, (ND) to build a problem profile so as to understand behaviour-over time of issues in the region and establish the complexity of the MAR — part of the problem structuring process. This is followed with a practical application of a participatory group model building which is a learning process that is expected to result in the co-production of knowledge and the identification of the problem drivers in a mineral active region. With a case study (ND) being considered in this context, the following sustainable development goals were considered in line with the key areas of the research focus: (1) absence of poverty, (3) good health and well-being, (6) clean water and sanitation (7) affordable and clean energy, (10) reduced inequality, (13) climate action, (14) life below water and on (15) life on land, (16) peace, justice and strong institutions.

Chapter 7

"To enable a system to perform effectively we must understand it—we must be able to explain its behaviour—and this requires being aware of its functions in the larger systems of which it is a part" - Russell L. Ackoff

7 Application of the MAR Framework in the Niger-Delta (Nigeria) as a Case Study

This chapter was aimed at structuring the problem which is the initial step in the application of the framework. For the purpose of applying the MAR framework, a case study was chosen, the Niger Delta which is an exemplar of a complex and problematic MAR. The scale of the research was discussed with the purpose of setting a limit in terms of the research boundary. I then highlight the history of the region including the global significance of the Delta based on its share of global oil and gas reserve. Secondary data on oil spill and gas flare were explored to prepare behaviour-over time graphs which empirically demonstrates the inherent environmental cost of extraction in the region. The impact of extractive activities was discussed with regards to oil spill and gas flaring as well as effects on environmental media. The approach served to build up information on the problem area, identify policy issues of concern to management and clarify the scope and magnitude of the problem. The resource governance regime of the ND was discussed, stakeholders were identified, and a participatory group model building workshop was conducted to generate information from stakeholders that will support policy making and management.

Since a case study have been identified as a first step in the process, the scale and research boundaries are discussed to highlight their implication to the research.

7.1 Establish Boundaries and spatially delimit the system

Delimiting an environmental problem either by defined boundaries of catchments, or bioregions for management is a fundamental step to holistic management of an environmental region because it involves the entire system. Boundaries are demarcations that enable management to be tailored to interest areas; they are virtual constructs (Manson 2001; Rebovich 2006) that allows a system analysist to conduct a representative inventory of elements in a catchment/system. According to Le Billon (2007) national-level data do not always sufficiently reflect “local realities”. This has motivated study and analysis at sub-national levels to understand the local contradictions and spatial characteristics of resource and environmental complexities. That is, some environmental harms created by mineral exploitation in MAR could be widespread while some are localised. Therefore, this study considers the ND as an appropriate spatial unit based on its physical processes, geomorphological, socio-political, and historical characteristic for understanding the interaction between ecology and geodiversity whilst recognising that people represent a geological and anthropological force that bring about environmental changes in a system.

7.2 Collect multidisciplinary data for problem structuring and for the purpose of defining the system

7.2.1 History of oil exploration in the Niger Delta

The Niger Delta Nigeria is situated on the Atlantic Coast of southern Nigeria in the South-South geo-political zone and is recognised to be the third largest delta in the world (Nduka et al., 2012; Osuji et al., 2010). It is situated on the continental margin of the Gulf of Guinea in the West Africa equatorial region between latitudes 3^{o} and 6^{o} North and longitudes 5^{o} and 8^{o} East. The region prides as one of the most fertile regions on the world one of the world’s richest crude oil tertiary deltas and repository of enormous ‘petro wealth’ hosting about, 5% of global oil and gas reserves (Nduka et al., 2008; Nduka et al., 2012) and the engine of the Nigerian economy. The Niger Delta region is richly endowed with natural resources, both renewable and non-renewable. Situated in the tropical rainforest, the ND habitat plays host to both marine and terrestrial biodiversity (Nduka et al., 2008) and a haven for some endemic species (Ebeku, 2004). On a broad base, the region has four eco-regions: freshwater swamp forests, mangroves, lowland rainforests, and barrier island forests (World Bank, 1995b) which provide services that span the regulation and purification of water and air; provision of food and medicines; soil regeneration and pollination; flood and climate control; recreation, education, cultural and spiritual rebirth. These and many others are summed up in the provisioning, regulating, cultural and supporting services; a classification bolstered by the (MA 2005). The Niger Delta region is quoted to have a population of approximately 30 million people in 2011 (Ogege, 2011) with linguistic, ethnic and cultural complexity (Watts 2004). Traditional economic activities of people in this region include fishing, farming, forestry, logging, boat making and sand mining (Ipingbemi, 2009). Prospecting for crude oil is dated to have begun in 1908 and pioneered by German company–the Nigerian Bitumen Corporation (Frynas, 2000) which explored for oil but discontinued due to the German aggression towards the British and the hostilities that ensued in the First World War in 1914. Because Nigeria was under British Colonial administration, the British leveraged Germany's loss of the war and took control and enacted the Mineral Oil Ordinance No.17 of 1914 amended in 1925 and 1946 to regulate the right to search for, win, and work mineral oils with the totality of the country as a concession entity with non-British companies statutorily barred from acquiring mineral oil rights in the entity. However, not until 1956 was oil discovered in commercial quantity in Oloibiri in today's Niger Delta region and has been exploited until date. The oil and gas resource of the region provide for local, regional, national, and international energy needs. Oil and gas exploration and production has been significantly associated with contamination of the environment through oil spillage, gas flaring or venting which negatively impacts the local ecosystem, human health and the economy (Ite & Ibok 2013). The Niger Delta region has provoked global interest not because of its rich and unique biodiversity but for its huge reserve of oil and gas resource that fuel many economies of the world and the massive environmental pollution caused by extraction and associated activities. The competing interest for renewable and non-renewable resources provided in this region present a complex interaction pitting the locals who depends on the local ecosystems for sustenance against the multinational oil companies interest whose interest is centred on oil and gas exploitation. The region is endowed with natural and environmental resources like clean air and water and unspoiled nature however, decades of oil and gas extraction has exposed the environment to varied degree of pollution and degradation. Communities in the region were peripheral to cash economy and sustainably thrived on the provisions and services of the ecosystem. Gradual and unabated destruction of the ecosystems by oil extraction and related activities without equitable and compensatory inflow of benefits from the resource wealth have led to environmental degradation, caused huge socio-economic problems, impacting non-income variables as well as the sustainability of the region. The interdependences of social, economic, and environmental issues support the need to understand these interactions as activity on one sector or variable usually have a knock-on effect on the other.

Remarkably, prior to colonial oil and gas exploration and exploitation in the region, there is evidence from both archived historical information and anecdotal evidence that the indigenous peoples of the Niger Delta had customary laws which served to regulate and protect native forests in many ways, and enforced by the custodians of custom many centuries before colonialism and the emergence of statutory laws (Ebeku, 2004). For example, through the declaration of certain forests and groves as sacred including customary conservation laws on fishing, hunting, water, and animals which served to regulate and manage activities in the region to ensure the sustainability of the resources and ecosystem services of the region. However, the capitalist oil driven economy, government need for foreign exchange earnings, the region's high quality of crude, alienation of customary laws and lack of robust and enforced statutory environmental laws in the region has caused near irretrievable environmental impacts in the region. Figure 7.1 is the map of the ND Nigeria showing its nine constituent states.

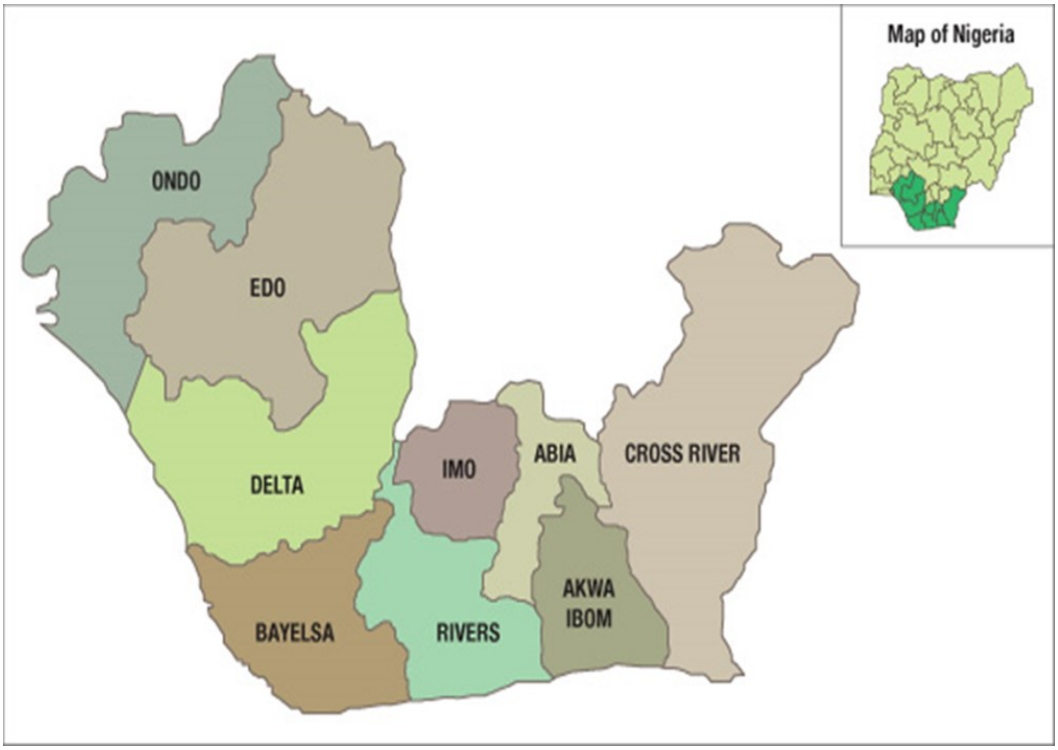

Figure 7-1 Map of The ND Region. Source: http://ndpifoundation.org

7.2.2 Biophysical and economic features of the Niger Delta catchment

- Geography
  - The Niger Delta is situated on the Atlantic coast of southern Nigeria between latitude 3^{o} and 6^{o} North and Longitudes 5^{o} and 8^{o} East (Nduka et al., 2008).
  - ~70, 000m^3 of wet land and ~20,000 km^2 of mangrove within the wetland
  - 3rd world's largest wetland and largest in Africa
  - Extensive swamp, mangrove and forest areas, with many unique species of plants and animals (Ebeku, 2004)
  - Susceptible to subsidence because of terrain and geomorphology
- Mineral Wealth
  - Oil discovered and commercially drilled in the region in 1958
  - Host about to 5% of the world's oil and gas reserves (Nduka et al., 2008)
  - The Niger Delta has about 606 oil fields (355 onshore, 251 offshore)
  - 7,000 kilometres of pipeline, 10 export terminals, 275 flow stations (Osuji, Adesiyan, & Obute, 2004)
  - 5,284 wells have been drilled throughout the Niger Delta Region (Nwilo & Badejo, 2005)
- Environmental, Economic & Social Impact
  - Between 1976 and 1997, about 5334 reported cases of crude oil spillages releasing ~2.8 million barrels of oil into the land, mangroves, waterways, estuaries and coastal region of Nigeria (Dublin-Green, Nwankwo, & Irrechukwu, 1998)
  - About 123 flaring sites (Uyigue & Agho, 2007)
  - 45.8 billion kilo watts of heat is discharged into the atmosphere from 1.8 billion cubic feet of gas daily in the Niger Delta region (Agbola & Olurin, 2003)
  - Loss of agricultural land due to degradation caused by spillage, acid rain.
  - Income inequalities (vertical and horizontal)

- Spatial overlap between oil and gas extraction and other resources such as fishery and other maritime activities

7.2.3 Environmental characteristics of the ND Ecoregion

The world bank sponsored survey report classifies the ND region in four ecoregional characteristic:

7.2.3.1 Freshwater swamp forests

These forests cover 11,700 km^2 of the Niger Delta. The freshwater swamp forests are most extensive in the west and central Delta and are located within flood plains. The freshwater forest band is much thinner because of the higher elevations in the eastern delta. Flood waters collect in numerous swamps and ponds, saturating the soil for at least the rainy season while standing water evaporates during the dry season in most areas (World Bank, 1995b). The swamp forest zone can be subdivided into two ecological groups:

- riverbank levees which are rarely flooded and have been mostly converted to agriculture and provides the best conditions for tree growth
- the back swamps which can be inundated with water for most of the year; it is the most heterogeneous of the main ecological zones, with diverse species of flora and fauna

7.2.3.2 Lowland Rainforests

This lowland rainforest ecological zone of the region represents the non-riverine or upland areas and covers about 7,400 km^2 of the Niger Delta. However, only a few lowland forests remain at present because of conversion to farmland. Part of the remaining the lowland rainforests may have a limited number of trees and found in relic shrine forests (World Bank 1995).

7.2.3.3 Mangroves

Mangrove refers to salt tolerant trees or shrubs with numerous tangled roots that grow above ground and form dense thickets that grow on sheltered shores and in estuaries located in the tropics and some subtropical regions of the world. The Niger Delta, is host to the estimated stretch of mangrove that cover between 5,400 km^2 and 6000 km^2

and contributes to the majority of the Nigeria mangrove which is the third largest mangrove forest in the world and the largest in Africa (9,730 km^2) and characterised by regular salt water inundation (World Bank 1995). The ND mangroves hosts and provides habitat for a variety of fauna and flora species. It also plays host the red mangrove tree (Rhizophora racemosa) with its characteristic stilt or prop roots; smaller black and white mangrove (Ebeku, 2004). Mangroves are recognised as carbon sinks and can sequester large amount of carbon in their soils for decades and centuries. Therefore, deforestation of mangroves results in the release of sequestered carbon which goes against rational climate mitigation arguments.

7.2.3.4 Barrier Island Forest

The barrier Island forests also called the beach ridge island is the smallest of the ecozones in the delta. They are freshwater forests found between the coastal beaches and the estuarine mangroves. It hosts rainforest species created by the high freshwater table. A large area of the barrier island forest is still found in the ND region and has concentrations of biodiversity except for those in the proximity of impacting activities in the region.

In line with the review of the case study, some pictures obtained from the 2007 United Nations Development Report (UNDP) funded program on the implementation of a public awareness and public participation programme in relation to mangrove depletion and proposed re-forestation in coastal Nigeria is presented in figures 7.2, 7.3A and B to improve the conceptual understanding of the region's natural environment.

Figure 7-2 Red Mangrove, a predominant flora in the ND (UNDP 2007)

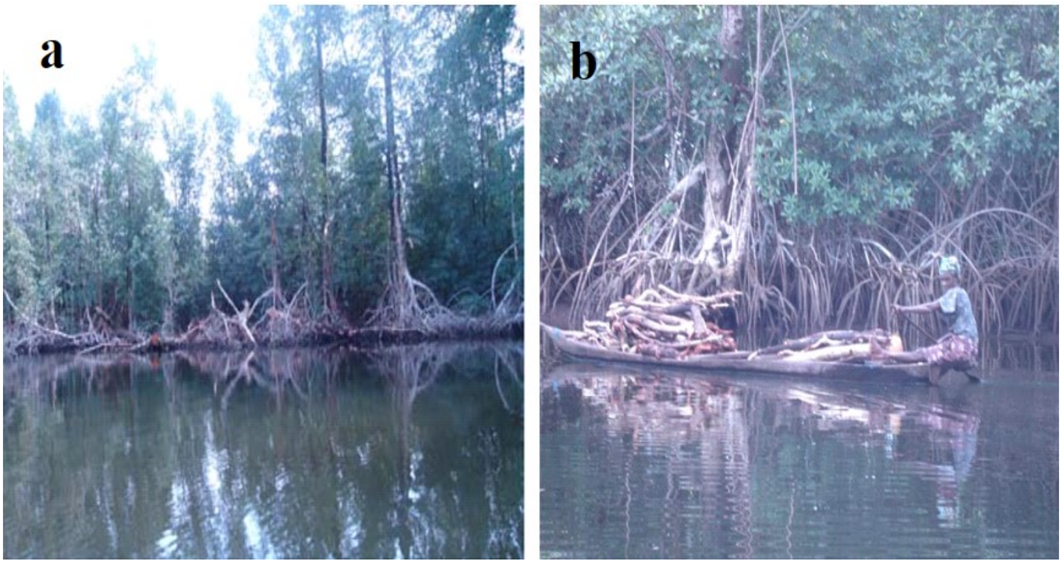

Figure 7-3 A And B: Felling Of Mangrove Wood along Abeugborodu Creek (UNDP 2007)

7.2.4 Impact of Extractive Activities

Every aspect of oil and gas exploration and exploitation comes with an attendant environmental impact which could be harmful to human and ecosystem health. Exploratory activities such as seismic operations to gather geophysical information; dynamiting and geological excavations can affect soil structure when carried out on land or cause serious narcotic effects when carried out on aquatic environments with resultant faunal mortality (Nduka et al., 2012). It can also result in the upset and destabilisation of the aquatic habitat. Construction of oil and gas infrastructure such as the pipelines, flow station, involves clearing and destruction of habitats for biodiversity and local ecological impacts. Produced water is a cocktail or heavy metals, radioactive materials and hydrocarbons that ends up in the environment whose effects are neither exhaustively researched nor fully known (Ite & Ibok 2013).

7.2.4.1 Oil Spill

The impact of oil, in either terrestrial or aquatic ecosystems attracts a lot of attention for reasons including its visual and disturbing effects. In considering the ecological effect of oil pollution, the type and amount of oil, exposure rate (acute, chronic) and the prevailing meteorological conditions impact the degradation and dispersion (Nduka et al., 2012). Dicks (1986) in his study states that the effect of oil on mangroves might be influenced by sediment in the mangrove area. The study further demonstrated that in muddy areas with limited drainage and poor oxygen availability, greater pneumatophores are produced by the black mangrove (Avicennia marina) leading to higher mortality compared to sandy soil where conditions are different with root system that is able to use oxygen from the interstitial water. The degree of spreading of spill following spillage influences the vulnerability of mangroves especially in the intertidal zone, where the respiratory structures are densely found (Da silva et al., 1997). It is known that large amount of oil spill in an area could cause hypoxia and acute toxicity on vegetation. Species that burrow are also affected by forcing them out of their burrows due to ecological stress while breeding is also impaired since mangroves offer strategic grounds in the breeding and nursery of a variety of commercially important aquatic and amphibious species. Rodrigues et al. (1999) concluded that oil in mangroves persist for a long time and the responses of the mangrove to the oil impact can be divided in four successive phases: initial effect, real structure damage, stabilization, and recovery. However, ecosystem recovery from such impacts requires a long time and may never be complete. Therefore, proactive actions must be taken to protect the ecosystem from pollution as that remains the most sustainable approach.

In the Niger Delta Nigeria, the existence of oil spills is undisputed, but the cause is always challenged and usually characterised by accusation amongst the different stakeholders. Following decades of oil exploitation in the Niger Delta, the mangrove ecosystems have been on the decrease due to destruction/clearance and oil spillage in the region caused by exploitation of oil and gas in the Niger Delta (UNDP 2007). The

FAO estimates that activities in the Niger Delta are eliminating approximately 3.5% of the forest annually (World Bank, 1995b). The Nigeria Department of Petroleum Resources (DPR) classification of oil spill places all oil spill in three categories: minor spills (less than 25 barrels of crude oil on inland water or less than 250 barrels discharged on land, coastal/offshore water); medium spill (between 25-250 barrels on inland water or 250–2500 barrels discharged on land, coastal/offshore water) and major spill (releases greater than 250 barrels discharged on inland water or greater than 2,500 barrel discharged on land, coastal/offshore waters).

Figure 7.4 is demonstrating the impact of oil spill in mangrove forests while figures 7.5A and B and 7.6A and B are those of the different mangrove species in some communities in the ND region.

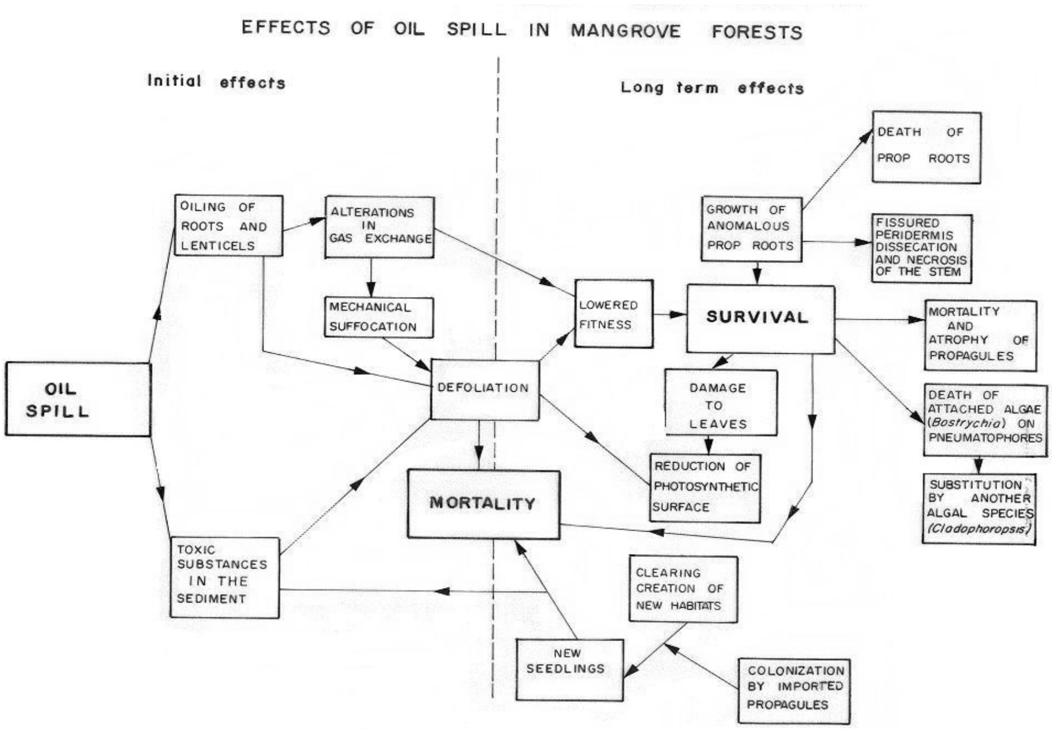

Figure 7-4 Impact of Oil Spill in Mangrove Forest. Source: Rodrigues et al. 1999

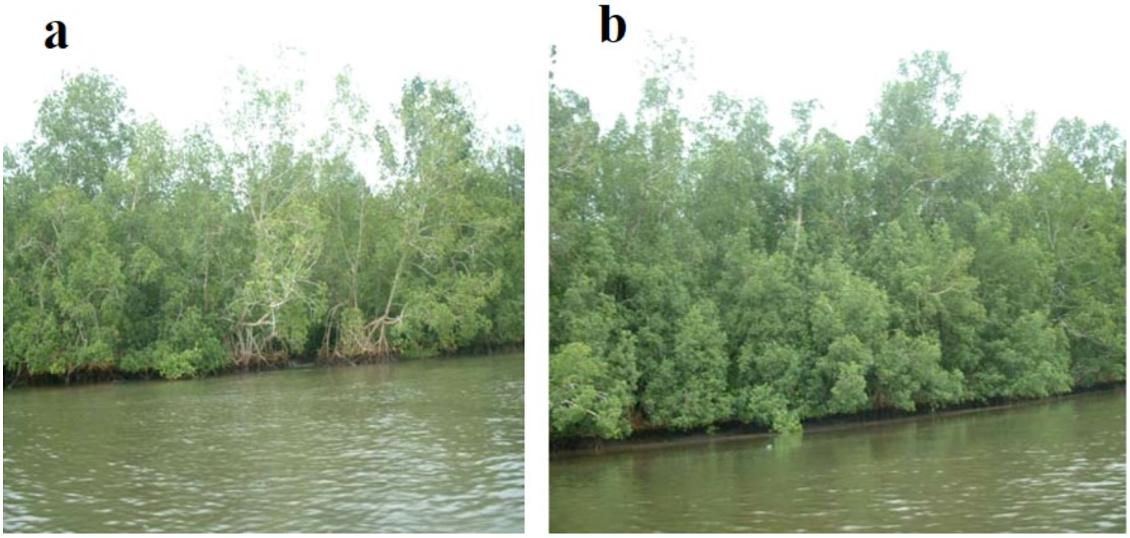

Figure 7-5 A And B: Mangrove Forest in Eastern Obolo of the ND Region. Source: (UNDP 2007)

Figure 7-6 A And B: Root Systems of white and red mangrove**:** Source: (UNDP 2007)

7.2.4.2 Gas Flare

Flaring is a common practice in the petroleum industry that is considered unsustainable and is being phased out with adoption of new technologies in many regions of the world for both economic and environmental reasons. Flaring is opted for as a way to dispose of associated natural gas during well development and when there is no infrastructure or market for the product (Ite & Ibok 2013). Flaring of gas generates noise and releases toxic gases, soot, excessive heat and radiant energy consequently increasing the thermal gradient of the locale (Ite & Ibok 2013). Among the chemicals released into the atmosphere are the volatile organic compounds (VOCs) like benzene, toluene, ethylbenzene and xylene (BTEX) and Polycyclic aromatic hydrocarbons (PAHs). The process also releases greenhouse gases that add to the global warming budget. This activity alters the microclimatic conditions of the immediate environment affecting physical infrastructures by means of acidic rain (Ekpoh & Obia 2010; USEPA 2017) as well as ecological receptors (Ana, Sridhar, & Bamgboye, 2009; Efe, 2010). The exploration of oil and gas is associated with sulphur and other harmful elements which combusts in the presence of oxygen to produce various sulphur oxides (SOx) which can combine with water to produce acid rain.

In the ND Nigeria, the government promoted a policy in 1979 to outlaw flaring in the region by 1984, except on a peculiar circumstance and with ministerial authorization. This was however not actualised. Flaring sites dominates the skyline and it is one of the most visible consequence of extractive activities in the Niger Delta. The stoppage of gas flaring was further moved to 2004 and 2008, however, despite the goal post shifting, this policy has failed to curb gas flaring in the region suggesting either intrinsic problem in the policy and/or the policy making process or lack of will to ensure enforcement. Whilst the environmental and socio-economic argument persist regarding the gas flare going on the Niger delta region, the incentive for associated gas recovery is poor considering that it is four times more in cost than the straight extraction of non-associated gas as well as the absence or lack of a well-developed market for the product (World Bank, 1995a).

7.2.4.3 Mangrove changes in the ND

In a study conducted by (James, Adegoke, Saba, Nwilo, & Akinyede, 2007) using satellite-based assessment tool to assess the extent and changes in the mangrove ecosystem of the Niger Delta, they found a significant decline in mangrove vegetation as a result of extractive activities of the oil and gas industries in the region including dredging and urbanisation. The figure 7.7 shows how a segment of the study area in the region have undergone some changes over the period under investigation. The patch highlighted in figure 7.7B shows changes in the exposed land as well as cloud cover compared to the baseline figure in 6.7A.

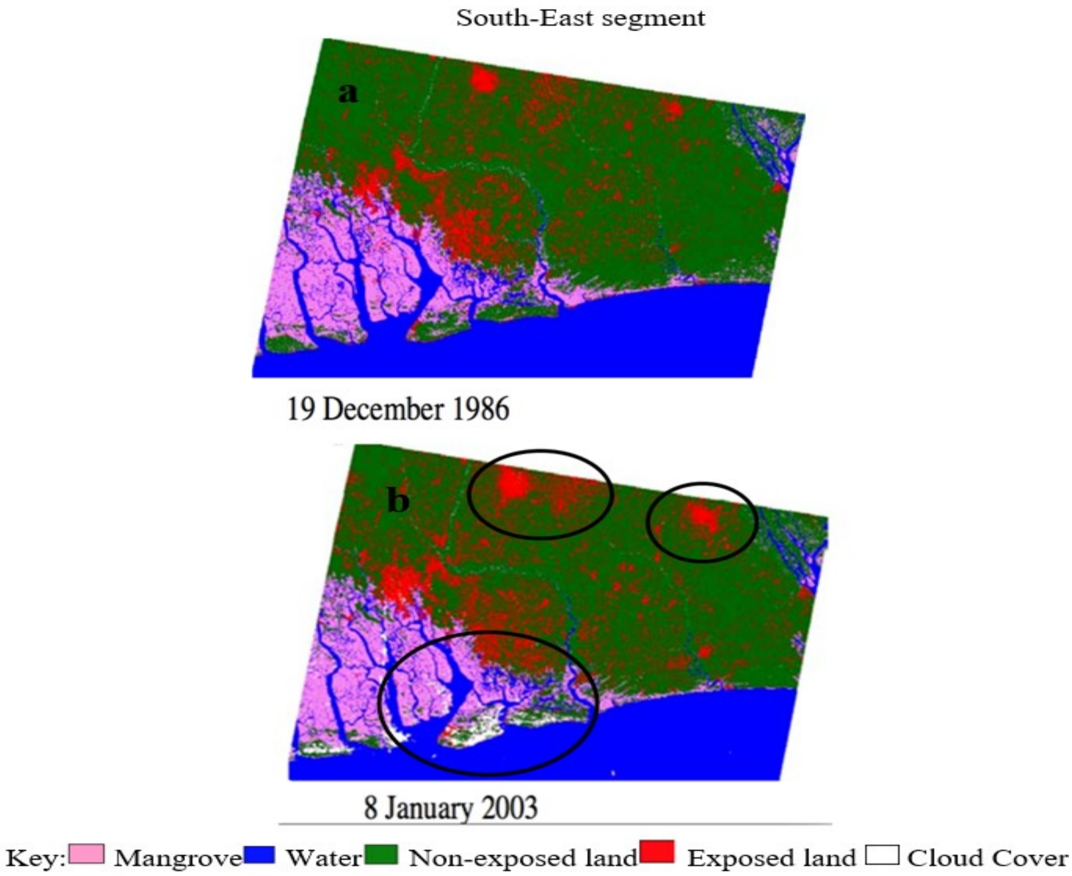

Figure 7-7 A And B: Change in ND Mangrove Vegetation 1986-2003**.** Source: (James et al. 2007)

7.2.4.4 Impacts on Environmental Media and Biota

Hydrocarbons are composed of alkanes (paraffins), cycloalkanes (naphthalenes) and aromatics. Polycyclic aromatic hydrocarbons (PAHs) belong in the last group and they are known to exhibit genotoxic and carcinogenic properties. Hydrocarbons have intrinsic characteristic property of altering the physical and chemical properties of environmental media they come in contact with depending on the quantity and concentration (Nduka et al., 2012; Obinaju et al., 2014; Olawoyin, Larry Grayson, & Okareh, 2012; Osuji et al., 2004). For example, a spill of volatile hydrocarbon on a sandy soil can evaporate fast whilst heavy crude on a loamy or clay soil can remain for several years and become a reservoir or source of pollution. Hydrocarbons even in small quantities can cause both physical and chemical effects in water including the prevention of oxygen transfer in the water column, thus affecting aquatic life-support systems whilst gas flaring contaminates the air by releasing different volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and green–house gases (GHG) in the atmosphere which contributes to global warming (Ite & Ibok 2013) and changes rain water chemistry (Ekpoh & Obia, 2010; Nduka et al., 2008). The fate of hydrocarbons in different media have been studied including potential health risk on different biota. In a comparative study conducted by (Ana et al., 2010; Ana et al., 2009) with focus in some communities in Niger Delta region, the study shows correlations between several disorders including cancer and congenital malformations for areas with high petrochemical industrial activities compared to areas with low activities. Humans and other ecological receptors could be exposed to hydrocarbon as a result of oil spillage and gas flare and therefore presents a potential health risk. The figure 7.8 is conceptual model of different routes of human exposure to oil spill.

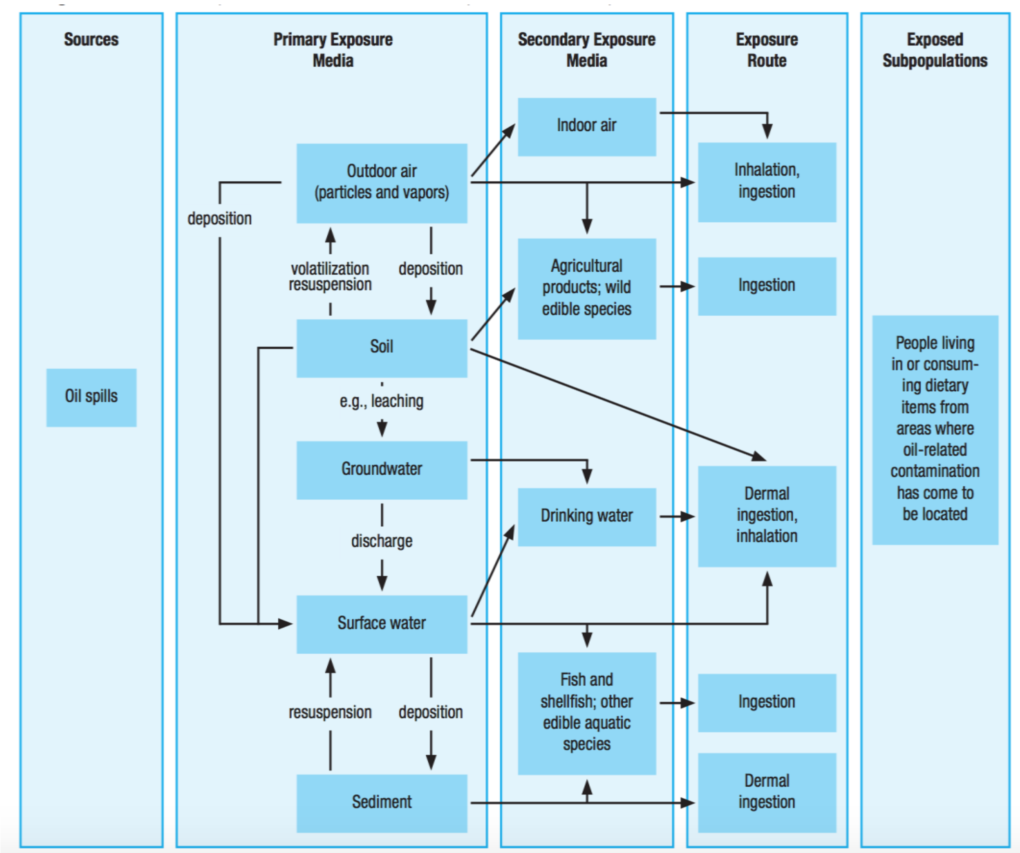

Figure 7-8 Adapted From: UNEP Environmental Assessment of Ogoni Land (United Nations Environment Programme 2011)

7.2.5 Graphical Presentation of Analysis of Oil Spill in the Niger Delta

Figures 7.9 and 7.10 are time series graphs of oil spill and gas flare respectively in the mineral active region of the Niger Delta Nigeria. The data represented in the graph is secondary data extracted from peer reviewed journals, non-governmental organisations (NGOs), and publication from government institutions. The graphs and the underlying information give an indication of what has been happening in the region over the years and constitute a reference for the environmental impact of extractive activities in the region.

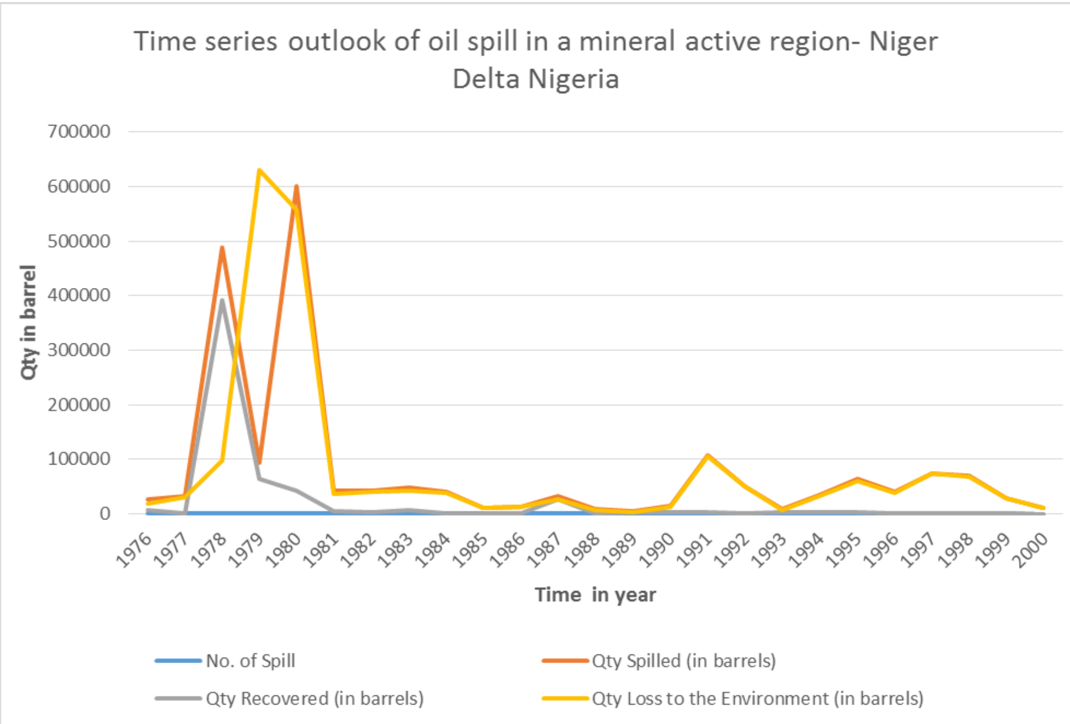

Figure 7-9 Graph Showing Oil Spill In The Mineral Active Region Over 25- Year Period Of Resource Extraction. Data Sourced from (Uyigue & Agho, 2007)

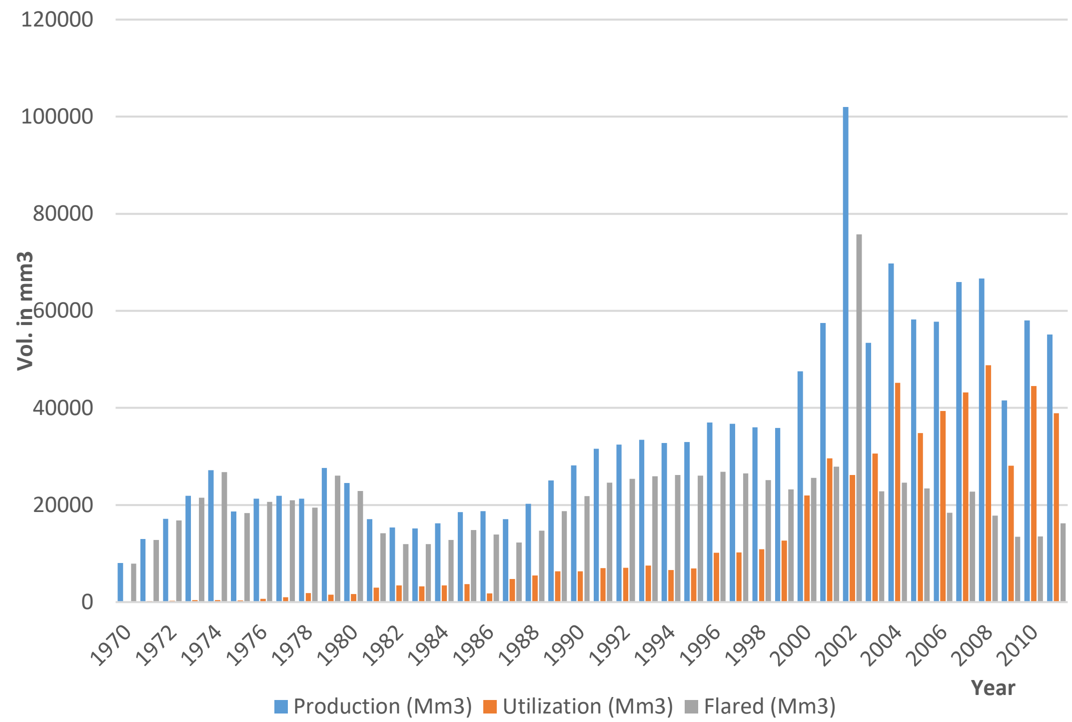

Figure 7-10 Time Series Outlook of Gas Production, Utilization and Flare Over A 40-Year Period of Resource Extraction in the Niger Delta

The trend of the graph shows that over the years, there was sporadic but consistent oil spill and continuous gas flare in the region. Major oil spill in the region include the GOCONS Escravos spill in 1978 as reflected in the spikes in the graph; Shell Petroleum Development Corporation (SPDC) Forcados Terminal Tank failure in 1978. Oshiko and Forcados terminal 1979 oil spill at estimated to be over 500,000 barrels. This resulted in massive oil release into the environment assumed to be the worst in the history. In 1980, a blow out at Funiwa and oil spill at Oyakam resulted in large quantities of crude oil estimated to be up to 200,000 barrels was lost to the environment damaging adjacent ecosystems and affecting thousands of livelihoods and recreational environments like beaches (Ipingbemi, 2009; Kadafa, 2012) including the destruction of 340 hectares of mangrove. There was over 40,000 barrels oil spilled in 1998. Reports show that only about 23.17% of the oil spill from 1997 - 2001 was recovered out of the total of 2,097 oil spill incidents. In 2008/2009, the Bodo community in the Ogoni of the Niger Delta region was heavily impacted by oil spill that last for more than 77 days with several thousand barrels of crude oil estimated to have been spilled into the environment and consequent destruction of Bodo's ecosystem. This event changed the ecological character of the community with pre- and post-spill survey showing a decline in the floral and faunal species, death of mangroves and eventual collapse of notable fisheries within Bodo Creek (Pegg & Zabbey, 2013). Half of the oil spill incidents were attributed to corrosion arising from maintenance failures, 28% to sabotage, 21% to oil production activities and 1% to engineering drills, careless loading and offloading of vessels. The spate of oil spills is spread across the entire geography of the Niger Delta. About 25% of such pollution in the 70s to 90s were dumped in the swamps, and another 69% occurred at offshore facilities and only 6% on dry land. The occurrences of 1981 and 1982 were reported to have been a result of technical failures while that of 1984 was reported to be a case of sabotage. Apart from these significant occurrences, there have been several other cases of oil spill in the region as shown in the graph. Studies conducted (Abowei, Ezekiel, & Hansen, 2012; Aprioku, 1999) reveals a decline in oil spill resulting from technical failures while those from sabotage has increased progressively. The time series graph for gas flare shows a progressive increase in the amount of gas flared over the 40-year period. For example, in the 70's 80's and 90's, almost all produced gas was flared (estimated around 75%) and re-injects only 12% to enhance oil recovery because of lack of gas utilization infrastructure in Nigeria. In recent years, there has been increased utilization of gas with a corresponding reduction in the amount flared. Despite the little progress made, the host region continuous to receives a large volume of flared and vented gases at high environmental, health and socio-economic cost.

Several studies looking at the relationship between the environment, economic and social variables have been conducted in the ND region as shown in **table 7.1**. Amongst these are studies that strongly associated hydrocarbon exploration in the region with socio-economic and environmental impacts (Adesopo & Asaju, 2004; Ipingbemi, 2009; Ite, Ibok, Ite, & Petters, 2013); human and ecosystems health effects (Ana et al., 2010; Ana et al., 2009; Gobo et al., 2011; Olawoyin et al., 2012); wetland/mangrove destruction and loss of associated social and economic benefits (Adekola et al., 2015; Ebeku, 2004); land use changes (Adekola & Mitchell, 2011; James et al., 2007).

Table 7.1 Recognised Environmental, Economic, and Social impacts associated with Oil and Gas Extraction in the Niger Delta Mineral Active Region.

Environment	Economic	Social
Oil spill, oil waste release, Gas flare (emissions), heat generation & stress.	Revenue loss from spill and flare, loss of coastal and mangrove resources such as abandonment of fishing grounds and general resource depletion.	Threat to health, safety and welfare, loss of employment.
Land use changes due to roads, platforms, and pipeline construction Physical alteration (deforestation/ ecosystem destruction)	Reduction of land available for agriculture.	Food shortage. Cultural impacts and risk to community by creating unregulated access to communities.
Microclimatic change, acid deposition via acid rain/acidic precipitation.	Loss of agricultural crops, aquatic life. Damage to physical structures via acid deposition and corrosion.	Adverse change in means of livelihood and recreational values.
Toxification, landscape changes, aesthetic depreciation.	Loss of ecosystems services through depreciation of ecosystem provisions and services.	Loss of landscapes and natural aesthetics. Loss of recreational spaces and loss of eco-tourism potentials

Table 7.1 highlights some environmental impacts of oil exploration and production in the Niger delta as shown from UNEP Environmental Assessment Report of Ogoni land. This occurs through seismic, drilling, and production activities as well as transportation and refinery.

Table 7.2 Summary of the Environment Impacts of Oil Exploration and Production from UNEP Environmental Assessment of Ogoni Land. Adapted: (United Nations Environmental Programme 2011**)**

Exploration and production activity	Physical activity	Impacts
Seismic activity	Setting up base camps	Land clearance Access creation Abstraction of groundwater Hydrological changes Sewage Solid wastes Light and noise pollution Introduction of alien and invasive species
	Cutting lines	Removal of vegetation, Access creation
	Seismic operation	Vibration, Noise
Drilling operations	Setting up base camps	Land clearance Access creation Abstraction of water Hydrological changes Sewage Solid waste Light and noise pollution Introduction of alien and invasive species
	Setting up drilling pads	Land clearance Access creation Hydrological changes
	Drilling operations	Noise Drill cuttings and drilling wastes Spills and leaks Light and noise pollution

Exploration and production activity	Physical activity	Impacts
		Nuisance odours
Production Operation	Facility installation	Land clearance Access creation Abstraction of water Hydrological changes Introduction of alien and invasive species
	Pipeline installation	Land clearance Access creation Spillages and leaks Fires Nuisance odours Pigging wastes
	Facility operation	Noise Discharge of water Wastes, e.g. from tank bottoms Spillages and leaks Fires Nuisance odours

7.3 Resource Governance regime and the Case of the Niger Delta

The colonial powers in Africa and other places truncated management by imposing their own rules and failing to recognise local resource institutions that existed several centuries (Elinor Ostrom, 2009). The Niger Delta people governed and managed their environment and natural resources through native laws prior to colonial intervention (Ebeku, 2004; Frynas, 2000). The discovery of oil in the region and its economic benefits to the government necessitated changes in the region's regulatory system by the government of the day. The Land Use Act of 1978 vest all land in the territory of each state government except land vested in the federal government or its agencies (Ako, 2009; Aladeitan, 2013; Frynas, 2000). Prior to the enactment of the land use act, individuals and communities had ownership of land and enjoyed its benefits. The offshore oil Revenue Decree No. 9 of 1971 vested the federal government the right of ownership of territorial waters, continental shelf including rents, royalties and revenues derived from petroleum operations in the states. The implication is that the government has complete control and governance over all-natural resources. Governance is the use of regulatory and allocative mechanism in the management of resources (natural, economic, and social) in which authority is exercised through formal or informal institutions (Akpabio & Akpan, 2010). Also, 'new governance' has emerged and described by (Howlett & Rayner, 2006) as a governing mechanism that is designed to embrace collaborative approaches among government and non-government actors from both the private sector and the civil society. Lockwood et al. (2010) presented eight principles for natural resource governance which includes: legitimacy, transparency, accountability, inclusiveness, fairness, integration, capability, and adaptability. The implication is that each of these principles is important in the effective governance of natural resources and when non-existent could undermine governance and resource management efforts. Rogers & Hall (2003) argue that poor governance leads to institutional failure and increases political and social risk and therefore a barrier to development. To ensure effective resource governance regime, the federal government of Nigeria established decrees, and passed several laws and parliamentary Acts (**table 7.3**). Some of the recent ones includes the Nigerian Oil and Gas Industry Content Development Act 2010 and a new Petroleum Industry Bill (Draft) currently before the National Assembly aimed at overhauling and restructuring the Nigerian petroleum industry by codifying different pieces of legislation into a single document (PIB, 2012). The Act was to ensure local content policies that can promote the development of backward and forward links into the local economy and to ensure government captures the full benefits of the resource wealth. The management of different aspects of oil and gas exploration falls under different government institutions. The Federal Ministry of Petroleum Resources (FMoPR) is the executive and parent institution supervising every petroleum industry operations being undertaken in Nigeria. The Nigerian National Petroleum Corporation (NNPC) participates in both the upstream and downstream sectors and manages the joint venture between the Nigerian federal government and foreign multinational corporations. Regarding the management of oil related pollution and contaminated land, the Department of Petroleum Resources (DPR) and National Oil Spill Detection and Response Agency (NOSDRA) are responsible (Ambituuni et al., 2014; Rim-Rukeh, 2015). The DPR is in charge of managing legacy sites while

NOSDRA oversees detection and management of emergency oil spills (Ambituuni et al., 2014; Rim-Rukeh, 2015), however, there is the problem of conflict due to poorly defined or conflicting roles between the two institutions. The Nigeria extractive industry transparency initiative (NEITI) provides a governance framework for transparency and accountability in reporting extractive industry revenue. To address the environmental and associated socio-economic problems attendant with mineral extraction in the Niger Delta, the government put in place regulatory measures and governance regime however, Akpabio & Akpan, (2010) argue that there is governance deficit. In my view, the deficit arises from poor resource accounting and enforcement in the region. The accounting measures do not adequately account for many of the ‘externalities’ (secondary effects/impacts of extraction) attendant with oil and gas exploitation. The management of a mineral active region that has a complex interaction of geodiversity and biodiversity in the absence of a holistic framework for policy planning is difficult because of diverse and competing interest that characterise these regions. Dialogue for economic security and sustainable development in the Niger Delta must recognise the huge economic and non-economic importance of the services provided by a healthy local ecosystems and underscore the fact that addressing the environmental problems in the region will have extensive economic benefits (Adekola et al., 2015; SDN, 2014). In the ND, interest in oil and gas extraction outweighs the interest demonstrated in preservation of the regions’ unique ecosystem. A study conducted by (Adekola et al., 2015) shows a staggering discrepancy of net monetary value of the ND wetlands/mangroves to households in the region estimated at ($25billion) in comparison to the value of oil and gas production valued one-third of the estimate. The study also shows that about 75% of the environmental costs of oil extraction is borne by the community whilst only retaining a comparatively small amount of the oil and gas wealth— a typical case of unequal exchange and scaler mismatch of resource cost and benefits. In protest to the environmental degradation of the Ogoni land in the ND, the Ogoni people in 1993 led by Ken Saro-wiwa began mobilising peaceful marches and campaigns which resulted in a civil unrest and the consequent execution of the campaigners by the military government of Gen. Sani Abacha (Ehigbor & Akinlosotu, 2017). Other pressure groups such as Ijaw youth council, (Watts, 2004) took up arms against “petrobusiness” and its political allies (Ibeanu, 2000) in protest of the environmental and social change occasioned by oil and gas extraction in the region. The failure to comprehensively address the continued degradation of the Niger Delta's environment caused by oil and gas extraction as well as the resource control rights are considered to be largely responsible for the problematic nature of the region (Adekola & Mitchell, 2011; Ebeku, 2004). The situation in the ND area is characterised by social complexity attributed to human and institutional interaction (corruption, poverty, inequality, jurisdictional conflicts, institutional inefficiency) as well as biophysical characteristics of the region. To regulate and manage activities in the region, the government through decrees and parliamentary acts enacted laws and have launched different policies and programs, however this has not been effective to address the environmental degradation and socio-economic problems of the region. The table 7.3 presents some of the legal and regulatory regimes initiated by the government in a bid to combating the problem of the region. I drew upon the contents and purpose for which the laws/Acts were created to infer the stakeholder affected. Stakeholders affected are grouped as operators, government, and communities. The 'operators' are majorly multinational companies and local companies that receive concession to explore and produce oil and gas (NNPC, 2019). The 'government' is the resource owner and regulator while the 'communities' are the people living in geographical spaces that host oil reserves in which extraction takes place within their immediate vicinity.

Table 7.3 Nigerian laws and parliamentary acts formulated to manage both oil and gas exploration and production and the environment.

Law/Act	Implication and summary of law	Stakeholders affected
The Mineral Oil (Safety) Regulations, 1963	Provision of personal protective equipment (PPE) and the safety measures for workers in drilling and production operation in line with international standards	Operators
The Petroleum Act of 1969	Prescribes rule for extraction and prohibits the discharge of noxious gases	Operators, Government, Communities
The Petroleum Drilling and Production Regulations – 1969	Empowers the oil prospecting license (OPL) holders to do practically anything in the area covered by the license	Operators, Government, Communities

Oil Pipeline act of 1965	Prescribes requirement for infrastructural construction including pipeline, aimed at preventing pollution of land and water bodies.	Government, Operators Communities
Land Use Act of 1978, Land Use Act 1990 (CAP L5 LFN 2004)	An Act to vest all land in the territory of each state except land vested in the Federal government or its agencies	Government, Operators, Communities
The Associated Gas Reinjection Act of 1979	Outlawed gas flare with deadline set for 1984 with only peculiar circumstance to permit flaring	Operators, Government, Communities
Petroleum regulation Act of 1988	Requires operators to implement acceptable precautionary measures to protect inland and coastal wetlands from oil pollution.	Operators, Government, Communities
The Federal Environmental Protection Agency of 1988 (FEPA)	The most important piece of environmental legislation in Nigeria. First environmental regulatory and enforcement agency; roles includes promotion of natural resource conservation and management. Creation of the National Policy on the Environment (1989)	All stake holders
Oil Pollution Act of 1990	Responsible for the prevention, mitigation, clean-up and liability	All stake holders
The Petroleum production and distribution Act (Act 353 of 1990).	Petroleum Production and Distribution (Anti-Sabotage Act)	Government, operators, communities
National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations of 1991	Management of Solid and Hazardous Wastes in order to preserve public health and safety and the environment	Operators, Government, Communities
The Environmental Impact Assessment Act (Decree No. 86 of 1992)	Requires an EIA where the proposed project or activity is likely to significantly affect the environment	All stake holders

Environmental Guidelines and Standards for Petroleum Industry in Nigeria 2002 (EGASPIN)	Form the operational basis for environmental regulation of the oil industry in Nigeria. Sets out the approach to be adopted regarding contamination of the soil and groundwater	Operators, Government, Communities
National Environmental Standard and Regulation Enforcement Agency Act of 2004 (NESREA)	To regulate the environmental space by enforcing environmental standards for sustainable development of natural resources (established after the abrogation of FEPA)	All stake holders
National Oil Spill Detection and Response Agency Act 2006	Established to target the oil industry; tasked with restoration and preservation of the environment to ensure extraction activities would achieve sustainable development.	Operators, Government, Communities
The Minerals and Mining Act	To ensure mine operators comply with the requirements guiding mineral development with regards to environmental space.	Operators, Government, Community
Endangered Species Decree Cap 108 LFN, 1990.		
Oil Pollution Act (OPA) of 1990		
Harmful Waste Act Cap 165 LFN, 1990.		

Apart from the National laws and Parliamentary Acts, Nigeria is signatory to and has been involved in many multilateral environmental conventions and protocols that have direct and indirect significance in mineral extraction and its implication in the Niger Delta Mineral Active Region. Table 7.4, although not exhaustive, presents the major ones of these.

Table 7.4 Major International Treaties & Conventions on the Environment to which Nigeria is a signatory

Title of Treaty or Convention	Date Signed by Nigeria	Date of Ratification	Date of Enforcement
International Convention on Oil Pollution, Preparedness, Response and Co operation			13/5/95
Convention on Biological Diversity (Rio Conference)	13/6/92		27/11/94
Framework Convention on Climate Change	13/6/92		27/11/94
Kyoto Protocol to the United Nations Framework Convention on Climate change		2004	
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	1971	2006	10/12/87
Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central Africa	23/5/81		05/8/84
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter			18/4/76
International Convention for the Prevention of Pollution of the Sea by Oil, 1954, as amended in 1962 and 1969			22/4/68
African Convention on the Conservation of Nature and Natural Resources, 1968	15/09/1968	02/04/1974	
International Convention on Civil Liability for Oil Pollution Damage (Ratification and Enforcement) Act		2006	

7.3.1 The Compensation Scheme

The spate of oil spill and gas flare in the Niger Delta has remained unabated whilst the government who is saddled with the responsibility of managing the economy and protecting the environment seems more concerned in rent collection than protecting the environment and the people (Omeje, 2005). This apparent conflict of interest is perceived to be skewed in favour of the highly capacitated multinational corporations operating in the region. Although there are pieces of domestic and international legislation to ensure environmental protection, they have fallen short in providing effective protection as well as adequate compensation for victims of environmental pollution from oil and gas exploration and production. For example, compensation is paid for destroyed crops, productive trees, or assets such as buildings. However, pollution and consequent loss of use of land and water resources is not considered (environmental damage done to the ecosystem) leading to the collapse of activities in some parts of the region (Pegg & Zabbey, 2013; Rim-Rukeh, 2015). For example, the fishing port in Bodo community in Ogoni land in the Niger Delta collapsed after 77 days of unabated oil spill that destroyed mangroves and resulted in massive decline in both floral and faunal species (Pegg & Zabbey, 2013). Even though compensation was made for claims on destroyed crops and other assets, the ecosystem services provided by the river in the fishing port community was damaged including diminished future use. Moreover, the compensation guidelines are below standard rates and not adaptive to reflect prevailing rates. Policies and guidelines on environmental management principles are not robust and adaptive to meet the evolving environmental and resource problem of the region that manifest as economic and social problem. For example, the land use act of 1978 caused dissatisfaction and resentment on the part of the communities who had prior to this time negotiated with oil companies for rent and compensation. With the enactment of the Act, the right to acquire land and dispose of it for public good was vested in the government and made the process of resource ownership complicated owing to its interference with customary rights (Frynas 2000). Frynas noted that oil communities enjoyed land rights and better relationship before the introduction of this piece of legislation but also argued that the introduction of the act enabled companies' easier access to land and oil resources. Although the right to adequate compensation is enshrined in the 1978 land use Act, the African Charter on Human and People's Rights which was ratified and enforceable from 1983 enshrined and promoted the right to adequate compensation from environmental damage (Article 21 and 24). The ultimate aim of compensation is to deter the polluter form engaging in practices that could cause harm to both the environment and the ecosystem (Grigalunas, Opaluch, Diamantides, & Mazzotta, 1998). The situation in the Niger Delta is different as the option of payment of fine has failed to serve as deterrent coupled with the skewed balance of economic considerations in the litigation processes. The transnational oil firms exploit the provision of no compensation for oil spill arising from sabotage by continuously holding poor villagers as complicit in acts of sabotage (Ekpu & Ehighelua, 2004). It is worth noting that some of the compensation undertaken was not obtained through litigation but through mediations, negotiations and out of the court settlement. The lack of standardisation of compensation guideline due to historically stipulated values that are not constantly reviewed and therefore non-adaptive to reflect real time cost for on-going damages as practiced by the Oil Producer Trade Section of the Lagos Chamber of Commerce (OPTS) is a significant weakness in the compensation and overall resource governance regime. For example, table 7.5 compares the government and the OPTS rate compensation for damage from oil activities. The comparison shows how small the official rates are compared to the OPTS rate. For example, the OPTS rate for rice in 1997 was 15,860 Naira ($724.66) per hectare whilst in 1995 government official rate was 1,375 Naira ($62.80). With adjustment for inflation in 1996 and 1997, the official rate would be in the region of 1,924 Naira ($87.87). This value is one-eighth of the OPTS rate (Frynas, 2000). From figures presented here, it demonstrates that regulation through the use economic instruments is grossly inadequate to deter acts that can lead to oil spill and consequent environmental degradation.

Table 7.5 Comparison Of Official And The OPTS Rate Compensation For Damage From Oil Activities. (Frynas, 2000)

Type of crop/ tree	*1995 Official Rate per Hectare/ Tree (in Naira)*	*1995 Official Rate Adjusted for 1996-97 Inflation (in Naira)**	*1997 OPTS Rate per Hectare/ Tree (in Naira)*	*1995 Official Rate per Hectare/ Tree (in US$)***	*1997 OPTS Rate per Hectare/ Tree (in US$)****
Rice	1,375	1,924	15,860	62.80	724.66
Beans	290	406	10,660	13.25	487.07
Yams	835	1,168	48,000	38.14	2,193.18
Cocoyams	625	874	16,000	28.55	731.06
Most vegetables	625	874	5,850-16,000	28.55	267.29-731.06
Mango tree	25	35	500	1.14	22.85
Banana tree	2.50	3.50	160	0.11	7.31
Plantain tree	2.50	3.50	160	0.11	7.31
Agbono tree	18.75	26.23	340	0.86	15.54
Timber hardwoods	50	69.95	600	2.28	27.42

*Inflation was 29.3% in 1996 and 8.2% in 1997. Source: World Bank (1995, volume II, annex M, 76. Cited in Frynas 2000

7.4 Identification of Relevant Stakeholders in the Niger Delta MAR

Many factors may influence an environmental issue — some of which humans can influence or regulate, others completely beyond human control. In this case study, we have highlighted how biophysical, extractive processes interact with implication on health, social, environmental, and economic variables. We found that governance and institutional problems contribute to the problem of the region, making it difficult to manage. Focusing on the activities, and potential problems in the region that has led to environmental degradation and poor socio-economic conditions in addition to the poor history of the region which is characterised by unfair policies emanating from poor resource and environmental governance regime (Aghalino, 2009; Jike, 2004), there is need for transdisciplinary understanding of the problem through stakeholder participation so as to be able to combat the challenges confronting the region. The diverse activities in the region involves different stakeholder and multiple actors with different objectives and conflicting interest coupled with partial knowledge and incomplete understanding of the systems which can result to both analytical and socio complexity. Knowing that complex systems consist of interconnected and interacting components as demonstrated in the conceptual model of the MAR presented in chapter 4, interaction among the different systems components result in emergent properties such as environmental degradation, conflicts, institutional failure, and corruption. Technical and quick fix solutions may not solve the problems unless rules governing the system and the interaction in the system changes. To change the rule, relevant stakeholders whose interests are underpinned by these various activities should engage, dialog, collaborate and share information as appropriate agents whose view and interest can provide solutions.

7.4.1 Relevant Stakeholders in the Niger Delta MAR

Subject/project experts play important role in identification and characterization of elements in a system and contribute to knowledge and understanding of a system's components. For example, engineers, environmentalists, ecologists, geologists, lawyers, geographers, sociologists, historians, conservationists, bring diverse and specialised knowledge that support the understanding of environmental problems. However, socio-ecological interactions are usually complex, and not easily addressed based on technical and expert driven knowledge. In my view, it requires the involvement of stakeholders to find solutions. Stakeholder identification is part of the problem understanding and solution finding. The process of identification of the stakeholders is not an easy task. The literature review conducted in this research was a means to identify some key stakeholders in the ND MAR. The stakeholders initially identified are those of public institutions, multinational oil companies (business sector) and communities. For public institutions, the Nigerian National Petroleum Corporation (NNPC), National Oil Spill Detection and Response Agency (NOSDRA), Nigeria Extractive Industries Transparency Initiative (NEITI), Federal Ministry of Environment (FMoE), Ministry of Niger Delta Affairs (MNDA), Niger Delta Development Commission (NDDC), Federal Ministry of Petroleum Resources (FMPR) were identified. Emails were sent out, but replies were only received from NNPC and NEITI, FMoE and NOSDRA. The initial business sector stakeholder identified was Shell Nigeria Exploration and Production Company (SPDC). Shell is the oldest operating multinational oil company in Nigeria and has a legacy in the Nigeria oil and gas sector. Others include Total E&P Nigeria limited and Nigerian Agip Oil Company. Non-governmental organisations whose activities are focused on the environmental sector in the region, for example; Centre for Peace and Environmental Justice (CEPEJ), Coastal and Marine Areas Development Initiative (CMADI). Other stakeholders include researchers working in this area and Community Development Committee (CDC) representatives from host communities. Although it is widely supported that use of a democratic process in the selection of stakeholders is a robust approach to selecting appropriate stakeholder. Key stakeholders were identified based on information generated from literature review and the identified stakeholders helped to identify other stakeholders in a snow-balling referral pattern or the so-called hydra model (Sanò & Medina, 2012). The process allowed for groups that are relevant to the research but not aware existed to be recruited into the research process because of the perspective they bring into the research. For example, it was an employee at NOSDRA that recommended the involvement of Institute for Peace and Conflict Resolution (IPCR) based on past joint activities while Department of Petroleum Resources (DPR) was recommended by an employee of NNPC. The recommendations were based on the fact that NNPC, NOSDRA and DPR are always involved in Joint Investigation Visit (JIV) when an oil spill occurs. JIV is a participatory process in which regulatory institutions, operators (oil companies), NGOs and community members undertake a visit to determine the cause and quantity of spill when there is report of oil spill. The multi-stakeholder process participation is to ensure transparency although the process has been criticised for lack of appropriate methodology and transparency (Rim-Rukeh, 2015). It is worth noting that the list/number of stakeholders identified is not exhaustive, but it is considered to be inclusive of the key stakeholder and serves the objective of the research.

The table 7.6 presents the participating key stakeholder institutions/groups in the extractive and environmental sector, their role, challenges/problems facing the organisation, the objective for which it was established, actions to be taken to support the functioning of the organisation, and consequences for failing to take action to address the challenges facing the organisations.

Information about the roles of the participating institutions and the objectives for which they were established is found in the Laws/Acts and Policy guidelines establishing them while interviews conducted with stakeholders from the participating institutions provided an opportunity to gain knowledge about the challenges facing their respective institutions and actions that can be taken to support them in order to actualise their institutional mandate. The information is presented in the table 7.6 while other details generated was useful in discussing the general findings of the thesis. Inference was drawn based on the available information to demonstrate the consequences of poor performances of the organisations. It is worth noting that there was no participant from oil company operators in an official capacity, but I had the opportunity to interview some oil workers in an unofficial/informal capacity (both those in active work and retired) who had worked for SPDC.

Table 7.6 Some of the stakeholders that participated in the workshop and fieldwork: their roles, interest, and challenges

Stakeholder	Role	Challenges/Problem	Objective	Action	Consequences
National Oil Spill Detection and Response Agency (NOSDRA)	Tasked with the responsibility of co-ordinating the implementation of the National Oil Spill Contingency plan (NOSCP). Has a leading role in ensuring timely, effective, and appropriate response to oil spill, as well as ensuring clean up and remediation of oil impacted sites.	Paucity of funds, lack of equipment, and technical knowledge, lack of skilled manpower, weak legal framework, regulatory overlap.	Preservation of the environment to ensure extractive activities would achieve sustainable development.	Increased funding, strengthening of the Agency's legal framework to resolves lacuna.	Increased oil pollution and environmental degradation since the agency has no penalty regime domiciled in its mandate.
The Federal Ministry of Environment (MoE)	Established to effectively coordinate and streamline all environmental matters through awareness, enforcement, and intervention.	Paucity of funds, lack of necessary equipment, and technical knowledge.	Ensure environmental protection, natural resources conservation and sustainable development.	Increased funding, training, and skilled staff.	Inability to contain environmental degradation.
Nigerian National Petroleum Corporation (NNPC)	State owned and controlled oil company which is a major player in both the upstream and downstream sectors and manages the joint venture between the Nigerian federal government and foreign multinational corporations	Bureaucratic bottleneck and the so-called principal agent problem. Inability to ensure unhindered access to energy resources.	Adding value to the nation's hydrocarbon resources for the benefit of all Nigerians and other stakeholders.	Strategic measures to reduce bureaucracy and streamline operations so as to increase capacity and optimise the gains in the system	Emergence and maintenance of black or illicit economy

Stakeholder	Role	Challenges/Problem	Objective	Action	Consequences
Nigerian Extractive Industries Transparency Initiative (NEITI)	To improve Nigeria's macroeconomic environment and public expenditure management; strengthening institutional and governance reforms.	Paucity of funds, lack of full disclosers from stakeholder institutions to allow for proper oversight.	To ensure accountability and transparency in Nigeria's extractive sector for the benefit of all Nigerians through good governance of the extractive sector.	Increased funding, training of staff, strengthening of legal instruments backing the institution.	Transparency and accountability problems in extractive governance institutions. Shrouded mineral agreement contracts and remittances
Institute for Peace and Conflict Resolution (IPCR)	Established as a think-tank agency to strengthen and promote peace and for conflict prevention, management, and resolution as well as building capacities and intervening in conflict hot spots. Conflicts between different interests often arise and therefore requires a well position institution to mediate.	The inability to utilise some alternative conflict resolving resources and channels. They are either not exploited or underutilised. E.g. conflict Resolution practitioners, traditional institutions. Lack of adequate funding and training of workforce.	Promotion of peace, conflict resolution and mediation.	Legislation to sanction the use of alternative conflict resolving resources and channels in settling conflicts and disputes should be created.	Degenerative conflict profile and exacerbated violent conflicts in MARs
Department of Petroleum Resource (DPR)	DPR has the statutory responsibility of ensuring compliance to petroleum laws, regulations and guidelines in the Nigeria Oil and Gas Industry.	Bureaucracy, lack of skilled manpower, lack of equipment	To ensure the sustainable development of Nigeria's Oil and Gas resources through effective regulation	Measures to reduce bureaucracy, capacity building, reduction of interagency conflict	Lack of staff with technical knowledge, interagency conflict

Stakeholder	Role	Challenges/Problem	Objective	Action	Consequences
Environmental non-governmental organisation/Civil Society	NGOs have become more influential and powerful actors in engendering accountable practices in corporate institutions by continuously challenging and influencing government policies. The acceptance and endorsement by NGO-stakeholders has become significant in extractive regimes. The campaigns championed by NGOs have raised the bar on best practices. They are strongly concerned about the effect of mineral extraction on the environment and social spheres and campaigns for environmental protection, social justice, and labour rights. They have been helpful in administering local development programs.	Paucity of funds to ensure continuous and robust public engagement as well as for training of staff and personnel.	Interested in sustainable use of natural resources, sustaining ecological integrity, and ensuring optimal economic benefits to communities.	Funding support	Absence and or gap in policy monitoring and oversight by independent organisation
Community development committee representative (CDS)	They are part of the community but serve as intermediary between the community and the oil companies.	Communication problems; not having the power and skills to influence company's decision. Conflict of interest.	To express and communicate the interest of the communities to companies and vice-versa	Empowerment of CDC representative	Poor community-company relationship
Fisher men's association	Dependent on the fishery for economic, food and cultural resource.	Decline in fish catch; which has been attributed to freshwater swamp and	Ensures sustainable practices based on local knowledge to avoid the	Environmental conservation measures,	Collapse of livelihood means and cultural activity. Loss of food

Stakeholder	Role	Challenges/Problem	Objective	Action	Consequences
		mangrove ecosystems degradation, oil spill and general environmental degradation	collapse of the fisheries resources in creeks and mangroves	engagement in aquaculture to compensate for the decline	source and other ecosystem services. Food scarcity.
Local communities	Host communities with mining or drilling operations located in their geographical space.	The local communities are usually affected by the activities of resource extraction in terms of environment and socio-economic dimensions. The host communities are usually on the front line and the first to be affected by resource extraction issues.	They want to benefit from mineral wealth and other benefits associated with resource extraction including job and infrastructural development.	Government must address the issue of resource rights whilst ensuring the equitable distribution of mineral wealth.	Involvement in illicit economy or conflict and civic unrest
Investors/operators	Multinational corporations are long-term investors/stakeholders with strong partnership with international creditors who offer financial services to such corporate bodies.	Resource extraction requires huge capital investment and involves either government's direct investment and/or multinational companies and need government security to secure its	Investors are interest driven and have their priority placed on economic returns of their investment.	Carryout out corporate social responsibilities to secure community approval and social license. Fund government to ensure favourable	Problems could have severe economic consequences for both government and investors as well reputational liabilities.

Stakeholder	Role	Challenges/Problem	Objective	Action	Consequences
		investments through robust legislation and physical security. There is pressure of quick return in investment which constrains operators to be short termist in their dealings.		legislation. Finance private security outfits to secure their investment.	
Academics/Researcher/ Media	They play a key role in ensuring sustainable practices and are involved in research that would inform and improve technical aspects as well as policy regimes in other to mitigate the ecological footprints in mineral active regions.	Paucity of grants and funds. Paucity and inaccessibility of relevant data needed in research.	To provide objective and empirically driven information that would benefit all relevant stakeholders.	Provision of funds and data	Lack or poor research outcomes

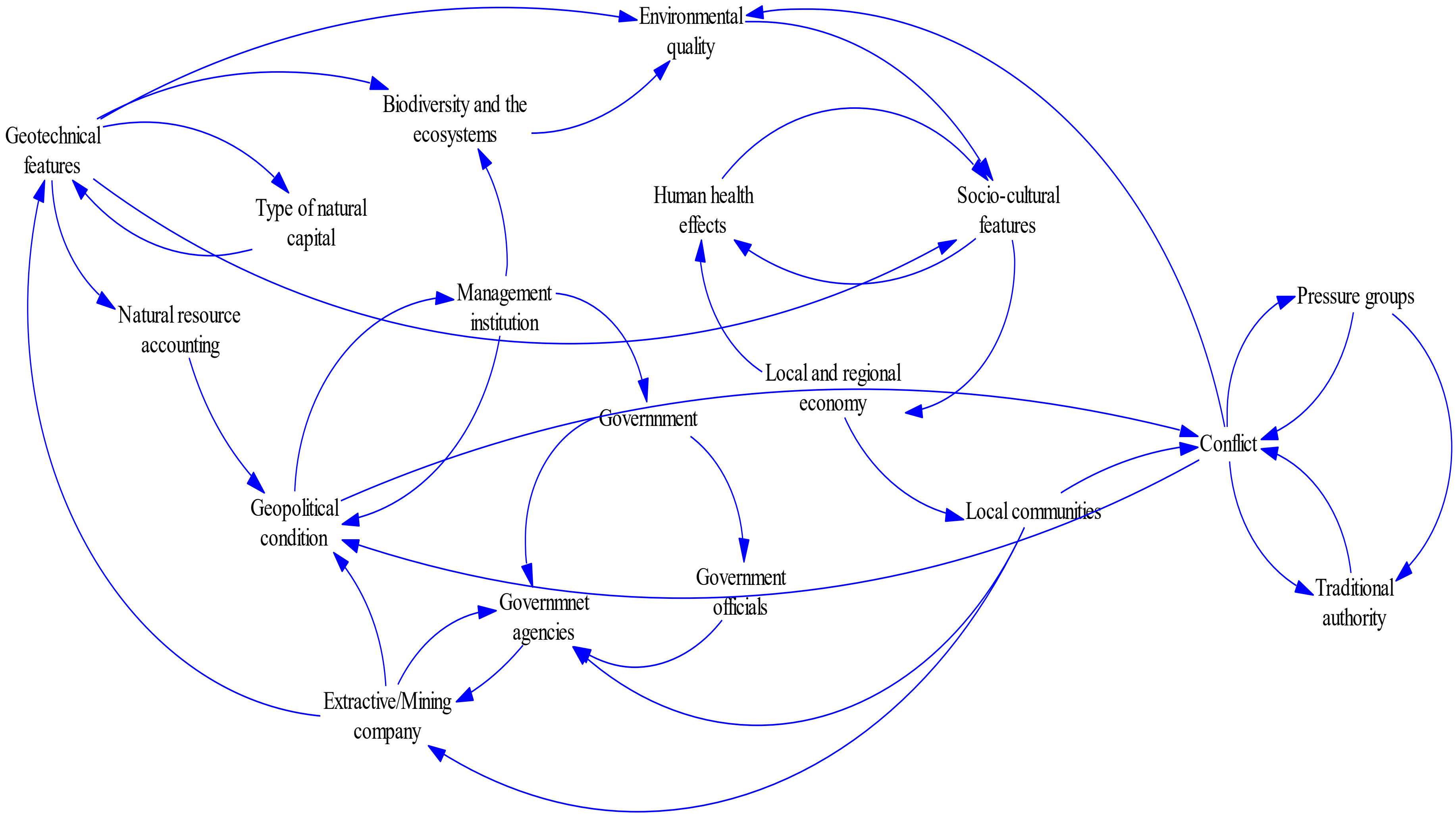

Figure 7-11 A systems map of the interactions between stakeholders and the systems components

7.4.2 A system map of the interactions between stakeholders and the systems components

The causal loop diagram in figure 7.11 shows an interaction between the systems component of a MAR as presented in figure 4.2 and explained in subsection 4.4.1 and stakeholders. In the causal loop diagram, geotechnical features describe a process of application technology in the extraction of geological resources. The process of extraction inherently transforms the environment. As shown in the loop, there is direct interaction between geotechnical features, extractive company, natural capital (subsoil resource), biodiversity and environmental quality. The outcome of that interaction also depends on factors that are not directly connected but can impact the system. Depending on the geo-extractive condition, the process can affect the local ecosystem and the environmental quality of the region. The process of resource extraction involves activities that can be socio-culturally intrusive because many extractive activities take place in remote environments which threaten the autonomy, survival and livelihoods of communities and indigenous peoples. Some of the negative externalities of extractive operations is the associated health effects, loss of agricultural productivity and healthy ecosystems which negatively impacts on local and regional economy considering that many of these remote communities live off the cash economy. This result (as in most cases) to protest and conflict which is championed and exacerbated by pressure groups which results in an unstable region and geopolitical condition. For example, groups/organisations such as Movement for the Survival of the Ogoni People (MOSOP), Ijaw youth Council (IYC), The Pan Niger Delta Forum (PANDEF), Movement for the Emancipation of the Niger Delta (MEND) and others have been on the frontier in the Niger delta. The management institutions are formal and resides with the government and administered through government agencies and officials who interact with both the oil companies and communities. The capitalist oil companies are driven to make profit for investors and shareholders while many of the oil workers are not indigenous and are neutral to the plight of the local people who feel government has failed to deliver. The discontent of communities toward the government and oil companies leads to more conflict that manifest in form of pipeline interdiction, kidnapping of oil workers and destruction of oil and gas assets which further affects the ecological conditions of the region including their livelihoods. Management is key to the problem of the region. The government owns the resource, participates in its extractive process through a joint venture agreement, manages, and distributes the resource wealth. Undue political influence in management was identified as a problem in the ND due to corruption and elite capture of resource wealth while the highly capacitated multinational oil companies wield a huge influence in the region including shaping of policies that impact extractive processes in the region. The government is at the centre of activities in the region and holds the power to ensure the sustainable management of extractive activities in the region.

7.5 The Participatory Process

7.5.1 Application of the systems thinking approach to a case study

This section is organised in two parts. The first part is focused on the participatory group model building process which is a learning process that results in the co-production of knowledge and the identification of the problem drivers in a mineral active region—the Niger Delta in this case study. The participatory process involves the engagement of stakeholders to learn, collaborate and build consensus through a shared mental model and interviews. The second part is the data analysis component in which oil spill data (2006-2017) obtained from National Oil Spill Detection and Response Agency (NOSDRA) was analysed and presented graphically to draw research relevant conclusions. Incorporating the data corroborates the argument presented in the research by describing actual happenings in the region such as time trends and condition and therefore a validation of the process. The reasoning behind the use of both qualitative participatory case study and quantitative data analysis in this study is that systems thinking supports the use of both to define and understand the problem situation in order to deliver a holistic and evidence-based outcome.

7.5.2 Issues for participatory discourse

The issues presented to stakeholders prior to starting the participatory process, are broadly subsumed under the reference areas stated below. These reference areas were developed from literature reviewed and information analysed in the case study area. They include:

- How communities in MAR can enjoy lasting benefits from mineral wealth extracted from the region while protecting human and ecosystem health as well as socio-cultural values.

- How communities can have more power to influence issues that affect their future and development as underpinned by mineral development and associated impacts.
- How global drivers influence local issues (climate change, resource depletion, social equity, local footprints).
- The perception of stakeholders on the potential impacts of projects on the lives of people as well as social problems that the presence of companies generates.

7.5.3 The participatory group model building

The participatory modelling session took place at the NNPC complex at the workshop room of the environment department. The participants were drawn from organisations/institutions whose activities are related or oversee the activities in the Niger Delta MAR as presented in table 7.6. It is noteworthy that all the stakeholders represented here were initially contacted through emails and/or phone calls. Official invitation letters were sent out and receipt acknowledged (see appendix 10). The invited stakeholders agreed to participate but some did not participate for reasons that were not communicated to the facilitator (researcher) while some could not due to logistics reasons. For example, none of the oil companies invited participated (SPDC, Total E&P Nigeria limited, NigerianAgip Oil Company) while CDC and the NGOs did not participate for logistics reasons.

Table 7.7 Stakeholder groups involved in the group modelling workshop and interview process

Stakeholder group invited for GMB workshop and number of representatives	Number of participants in attendance	Stakeholder group in attendance for GMB workshop	Interviews
NOSDRA	2	✓	✓
FMoE	2	✓	✓
NNPC	4	✓	✓
IPCR	4	✓	✓
NEITI	2	✓	✓
MNDA	—	✗	✓
FMoPR	—	✗	✗
NDDC	—	✗	✗
DPR	—	✗	✓
CEPEJ (NGO)	—	✗	✓
CMADI (NGO)	—	✗	✓

CDC	—	✕	✓
SPDC	—	✕	✓
Total E&P Nigeria limited	—	✕	✕
NigerianAgip Oil Company	—	✕	✕
Fisherman (community)	—	✕	✓

Key: ✓ Participated. ✕ Did not participate. — Not represented.

Table 7.8 Summary of the participatory activity

Activities	Niger Delta mineral active region
Total number of workshops	2 days
Average number of participants	14 heterogenous background
Modelling focus	Research
Systems thinking tools	Group model building
Facilitation material	Computer, projector, flip charts, workbooks, stick-it notes, questionnaires
Model sectors	Environmental, economic, and social
Process complement	Post modelling interviews, observations, and reconnaissance visits.
Workshop	Problem conceptualisation, variable elicitation and description, conceptual model formulation

7.6 Participants views and the participatory outcome

Many of the stakeholders from the participating institutions are desk officers directly working on programs/projects related to activities in the region and therefore had good knowledge of the system (case study) in terms of its ecology, environment and associated management problems, resource governance, local culture, and history. This was important to ensure the right representatives were participating. At the beginning of the workshop, the issue of discourse was introduced with a short presentation made by the facilitator (the researcher) to stakeholders/participants in the participatory workshop as a form of introduction to the exercise. This was an opportunity for participants to see the challenges of the region from a research perspective and how dynamic they are due to extractive and associated activities. After the presentation, participants were given a cardboard, pen, pencil, and a *post it* cards and asked to write their perceived problem of the region (the system) on the *post it* cards and place them under a description on the cardboard "current state". They wrote down different issues and placed them on the cardboard. This was a process of brainstorming to generate as much idea as possible and generally referred to as divergent thinking. The ideas/concepts written down by the participants were clustered and placed in four groups by the facilitator based on similarities of the concepts: environmental, economic, social, and institutional which constitutes the four paradigms of sustainability. Participants were asked to check if they agreed with all the concepts listed were pertinent to the research discourse. Following the question, some concepts were excluded by participants for not being directly linked to extractive processes in the region. These include both anthropogenic and natural drivers of change (dredging, invasive plants, damming, coastal erosion, flooding, wetland land reclamation). After grouping the concepts, participants then engaged in a structured session guided by the facilitator. The facilitator encouraged participation whilst being neutral yet showing curiosity. Costanza (1999) considers a researcher as a stakeholder and argues on that basis they cannot be neutral and therefore suggests that an external person should serve as a facilitator. This could hold true depending on the interest of the researcher, however, Vennix (1996) maintains that amongst other skills required, the facilitator's attitude should be neutral. This guided the researcher to maintain a neutral attitude during the workshop. The deliberation process was open and overall constructive. Participants showed genuine interest in understanding the views of other participants. There was no serious conflict except for differing opinions on some issues amongst participants. The process of deliberation allows for knowledge fostering and to deconstruct "silo thinking", fostering learning and insight. After the deliberations, each participant was asked to write what an ideal state of the MAR systems on their *post it* cards and place them under the description "ideal state" after which they were collectively asked to create a policy response to the identified problems. The participants found it difficult to create a policy response. In my view as the facilitator, the challenge was because the problems were described mostly on physical terms without consideration to the real or underlying issues that drive the changes observed in the region. The researcher (facilitator) asked the participants to think about the concepts they have listed to comprehend if they are the real problem or the symptoms of the problem. The facilitator suggested that participants should think and consider what could be responsible for the problems observed (problem drivers). Most of the problems listed were observed physical manifestations of the problem but when asked to reconsider the problem they began to see the problem from a management as well as political perspective. However, some participants maintained that the problems were the physical issues already listed by participants which is presented in table 7.9 while some agreed that the problems had socio-political underpinning and therefore the issues/concepts listed were a manifestation of the problem. This is not unusual because what constitute a complex problem may not be easily understood because symptoms can be misunderstood to be the problems (Franks et al., 2013). According to Hjorth and colleague, it is through non-linear and organic way of thinking that complex problems can be understood (Hjorth & Bagheri 2006). Due to the disagreement on what constitutes the problem of the region (either the observed physical issues or socio-political issues/drivers) a voting process was conducted to allow participants to decide what the real problem was so as to resolve definitional differences and to have a shared vision of the problem and corresponding objectives. This is because a problem cannot be solved without properly understanding the problem cause. Majority of the participants voted 11 (eleven) in favour of socio-political drivers underpinned by poor governance, weak legal and management framework while 3 (three) voted in favour of the physical manifestations. The new consideration drove the conversation and participants agreed that the real problems were managerial and socio-politically driven which manifests as the observed environmental, social and economic problems. Following that, comparison of the "current and ideal state" of the ND was assessed on the basis of institutional capacity, management and governance as presented in table 7.10. The table demonstrates an effort by participants to explore the current institutional, policy and legal constraints that is responsible for the observed problems in the region and suggest ways to improve the system.

After the deliberations on the institutional issues, participants explored the problem of oil spill which has beleaguered the ecology and economy of the region. For example, pipeline interdiction and vandalisation was highlighted by all participants as a major problem in the region with ceaseless attacks on oil and gas infrastructure. Therefore, the participants explored the problem or concept in order to identify the drivers, actions, justification and intended outcomes of such actions. The variables or concepts produced in this process was outcome of a unanimous agreement expressed by a raise of hand which was an approach to reach consensus. Participants were asked questions after reflecting on the information elicited so as to avoid counterfactual thinking. Consensus was reached during the process by looking into different views or opinions and agreeing in a process of convergent thinking which was followed by simple voting through a raise of hand as the framework did not provide any guided structure to reach consensus. At the individual level, it can be argued that each participant's mental model was elicited while at the collective level, it allowed for shared knowledge and consensus on the problem of discourse. It is noteworthy that there were no pre-meeting sessions prior to the GMB workshop, although they are recommended in most cases, but there were post modelling interviews which afforded the facilitator opportunity to generate more information from different participants.

The information in table 7.9 is the initial concepts generated by the participants during the group modelling activity presented as the problem of the region which is put in four key groups. The information presented in this table is the outcome of the initial exercise conducted to generate idea/concept about the region before the participants were asked to explore the problem through the lens of institutional and governance framework presented in table 7.10. Many of the concepts presented in table 7.9 are external or observed physical expressions of the problems in the region.

Table 7.9 Initial and ideal State of the ND Mineral Active Region based on physical manifestations and observed social problems

Sub-system	**Initial concept of problem in the ND region**	**Initial concept of ideal state of the ND region**
Environment (Biophysical)	Oil Spillage, gas flare, acid rain, climatic change, fishery decline, biodiversity loss, ecosystems impact, oil waste and operational discharges, deforestation, seismic impacts, artisanal refinery, subsidence, pipeline interdiction (bunkering).	Clean environment, absence of oil spillage, stoppage of gas flaring, preservation of the biodiversity, absence of air pollution, absence of illegal refinery activities.
Economic	Natural resource depletion, lack of employment, absence of financial benefits to communities, poor economy in communities, poor/absence of infrastructure, artisanal refinery, pipeline interdiction to make money.	Gainful employment, improved revenue, proper distribution of resource revenue, availability, and access to refined products.
Social	Eroding cultural heritage, conflict and civic unrest, insecurity, inequity, human rights issues, poor access/lack of good education, human health problems, demographic change, corruption, poverty, pipeline interdiction (bunkering).	Preservation of cultural heritage, absence of conflict, safety and security of workers and communities, distributive equity, intergenerational inclusions, access to education.
Institutional/ Governance	Unstable geopolitical condition, poor public participation, transparency issues, ineffective legal frameworks, institutional compartmentalism, bureaucracy, corruption, ad-hoc and short-termist reaction to problems.	Transparency and absence of corruption, full public participation, good legal system, good institutional capacity.

Table 7.10 Comparison of the current and ideal state based on the institutional evaluation and analysis.

Elements of the current condition/state of MAR	Elements of the ideal condition/state of MAR
Overlapping institutional responsibilities, poor coordination and communication amongst agencies and absence of long-term planning, lack of prioritisation of environmental issues.	Open, transparent, and effective institutions with delineated and non-overlapping institutional responsibility. Institutions should concentrate on capacity building in critical areas to improve the ability to implement their mandates by focusing on the priority and emerging problems including monitoring and enforcement capacity.
Absence of a holistic policy framework that captures the essence of the system resulting in the dominance and prioritisation of one components of the system (e.g. the oil and gas industry) against other industries.	Coexistence of extractive activities with other industries, such as the fisheries and other agro-allied industries whilst maintaining the structure, functioning, productivity, and diversity of the region's ecosystems.
Inefficient market-based incentives, regulatory deficit, slow legal process, poor coordination of enforcement of environmental regulations.	Robust market-based incentives; strengthened legal framework to meet best practices.
Corruption, paucity of funding, lack of capacity and technical expertise. Poor agency capacity to implement monitoring and enforcement, limited funding, and reliance on limited federal or state budget allocation	Adequate funding through the creation of a revolving fund financed by oil companies as well as government budgetary allocation. Transparency, and accountability of managing institutions.
Inadequate compensation for damage to property and victims of oil pollution as well as the sustained disenfranchisement of the environment by environmentally unsustainable extractive activities.	Appropriate liability and improved access to compensation for victims of oil pollution. Robust compensation and penalty regime. Enfranchisement of the environment through targeted environmental policies.
Absence of basic infrastructure (power, piped water and sanitation,	Provision and access to amenities, infrastructure, technology, education, information.

Elements of the current condition/state of MAR	Elements of the ideal condition/state of MAR
roads, telecoms, education, health care).	
Inequality and inequity in distribution of resource benefits and costs.	Distributional equity, absence of both vertical and horizontal inequality. Appropriate mechanism to transmit wealth to ensure intergenerational equity.
Mixed instruments that are neither adaptive, responsive nor evolving with the pace of the industry and the environment.	Proactive and adaptive policy regimes, use of a mix of instruments, improved legal frameworks and regulatory environment that is responsive to the changing dynamics of a system.
A region on the threshold of irretrievable negative environmental and socio-economic footprints caused by poor integrity of oil and gas assets and infrastructure.	A healthy region characterized by good ecological health status, security, and absence of conflicts. Good integrity of oil assets and infrastructure and stoppage of flaring and venting and associated acts.
Results in ceaseless gas flaring and venting and oil spill.	
Development unstainable	Towards sustainable development

7.6.1 Post Modelling Interviews

After the group modelling session, follow-up interviews of participants were conducted. The interview section was not originally part of the research design but was a decision taken during the workshop given that the process could provide information that will support the research. The participating interviewees were told they would be recorded but information generated would be anonymised. The recorded interviews were transcribed onto paper and information generated used in the discussion of the research. In general, twelve (12) people were interviewed on the course of the research. The table 7.11 shows the participating organisation and the number participants interviewed in the process. Some stakeholder groups (CDC, farmers, and NGOs) who did not participate in the workshop were interviewed differently on a separate day and location. The interview constitutes part of the information presented in table 7.6 regarding the challenges and problems facing the organisations and the actions that can be taken to combat and manage them. The information generated from the interview was useful in discussing the research outcome.

Table 7.11 Interview participants and number of interviewees

Organisation/respondent	No: interviewed
NOSDRA	1
NNPC	2
IPCR	1
FMoE	1
NEITI	1
MNDA	1
CEPEJ (NGO)	1
CMADI (NGO)	1
CDC	1
A fish farmer	1
SPDC	1 (unofficial capacity)
Total E&P Nigeria limited	none
NigerianAgip Oil Company	none

Figure 7.12 is a model arrangement for the participatory engagement in a group model building process. Figure 7.13 is a picture of a group model building process with a group of stakeholders taken during the workshop designed to generate knowledge about the ND-MAR.

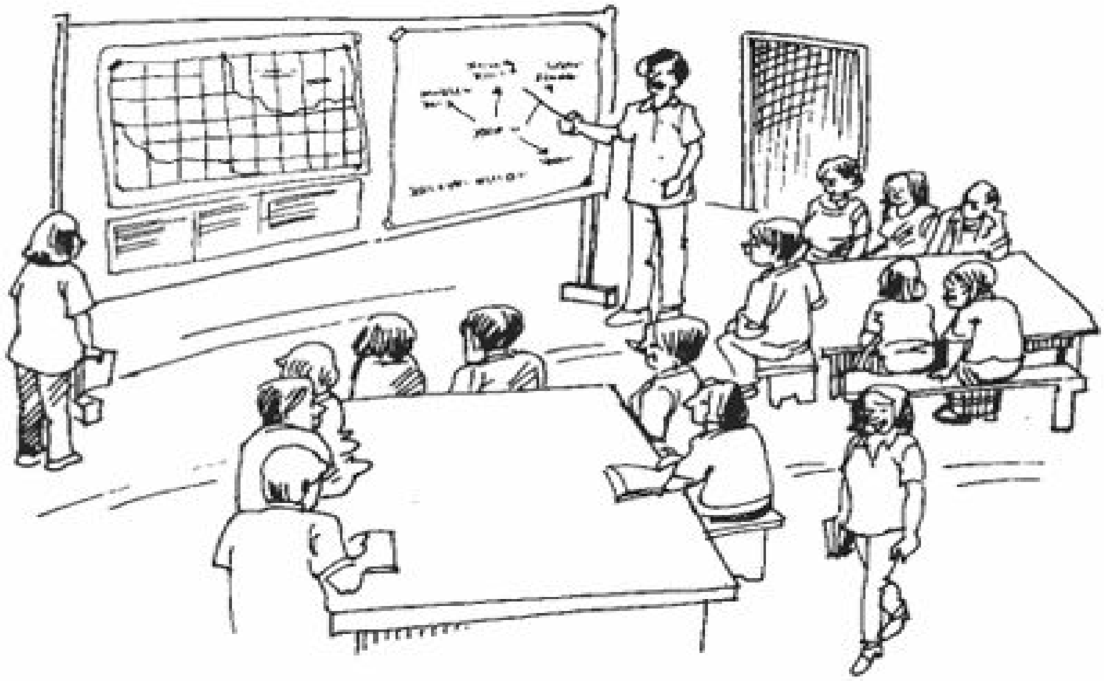

Figure 7-12 Example of the participatory workshop format. Adapted from (Sanò, 2009)

Figure 7-13 A Group modelling session with a group of stakeholders

Figure 7.14 shows an interaction with a fisherman who has taken up aquaculture to maintain livelihood because of the decline in traditional wild fishing. This represents a significant economic as well as socio-cultural change and a link in which extractive activities results in environmental contamination which in turn results in a decrease in wild fishing and farming activities with a loss in community income and change in lifestyle. Another important extractive externality that results in the loss of agricultural productivity which translates into lower yields.

Figure 7-14 Aquaculture being set up in several communities in the Niger Delta to engage communities whose natural ecosystem have been damaged by anthropogenic activities.

Figure 7-15 Oil-slicked mud on the shore of the Bodo Creek — a fishing community in Ogoniland. Courtesy (Reuters).

Oil spill from a damaged pipeline led to a heavy contamination of the community which resulted in the collapse of the fishing port in the Ogoni land in the Niger Delta.

Figure 7.16 presents a picture of a non-functioning NNPC floating filling station designed to provide petroleum products in the community to combat the sabotage of oil arising from absence of the products in remote communities. Inquiry made from members of the community indicated that the facility functioned only briefly after construction and commissioning. However, when this was mentioned and discussed with staff of the NNPC, they argued that the floating filling/service stations were serviced like every other stations across the country but also suggested that that "increasing insecurity, vandalisation of facilities and ability to access affected areas could contribute to maintenance and service issues". Although the accounts from both communities and staff of the national energy company (NNPC) differ, field observation confirms that the facility was non-functioning at the time of visit.

Figure 7-16 a non-functioning NNPC floating filling station in Osiama Creek and Ogubiri River

Figure 7.17 is a picture taken during the field observation/reconnaissance visit of the region and reflects the living conditions of some communities in the ND region. Many rural communities lack basic amenities despite decades of oil extraction in the region.

Figure 7-17 the picture reflects the housing and living conditions of an indigenous community in the Niger Delta region

7.6.2 Outcome of the participatory process: drivers of pipeline interdiction in the region

The information elicited from the GMB workshop revealed that a combination of environmental, economic, social, and political factors was responsible for the problems and the policy-resistant scenarios observed in the Niger-Delta region. The participatory approach in addition with dialogue interviews revealed some underlying drivers in the region. Presented in table 7.12 are some of the drivers, actions, justifications, and the intended outcomes of the activities in the ND MAR as revealed through the participatory approach and interviews conducted. It is worth noting that the process of deliberation was unanimous and there were no differing opinions. Therefore, the outcome was based on the consensus of all participants.

Table 7.12 Drivers, actions, justification, and outcomes of activities in the ND-MAR

Driver	Action	Justification	Intended outcome
Resentment due to unemployment and poverty.	Pipeline vandalism	Historical marginalisation by oil companies and government.	Draw the attention of government and multinational companies to address the environmental and socio-economic concerns of the region.
Demand for cheap crude abroad and cheap refined products locally (which is usually in short supply).	"Bunkering" of oil (in Nigeria means the deliberate and clandestine siphoning off or diverting of oil from storage facilities or through pipeline interdiction)	Inability of the government to supply and maintain affordable and accessible supply of products. Some people from the region feel a need to benefit from their natural resource wealth.	Provide employment opportunities to communities. Supply oil and refined products to local and international markets.
To gain wealth, political power and status.	Sponsoring the stealing of oil (Bunkering)	Desire for wealth and affluence, recognition, and access to political power through access to extractive commodities and consequently	Secure the loyalty of the 'boys' by providing livelihood means whilst maintaining the supply of crude to

Driver	Action	Justification	Intended outcome
		establishing themselves as “stakeholders”, Kingpin or Kingmaker.	international syndicate and raw material for local artisanal refinery.
To provide job for locals	Vandalisation of oil facilities and infrastructures.	Unemployment creates incentive for vandalisation to secure clean-up and security contracts.	Contractors secure clean-up contracts, pipeline, and surveillance contracts
To get cash payment	Vandalisation of flow lines and oil assets in the vicinity of properties and economic resources	To capture some of the oil wealth derived from the region	To secure compensation for damaged resources and possibly attract social amenities
Siting and naming of oil company projects	The siting and naming of projects on disputed land between disputing communities with oil companies in the intersection of such disputes results in litigations, and conflicts to secure custodianship of projects amongst communities	Sentiment of favouritism and disenfranchisement of communities by siting and naming of projects in communities where they do not belong based on high level lobbying.	To secure custodianship of projects and associated benefits.

Findings from the study show a link between economic issues and social problem for example, the sustained black/illicit economy in the region has become self-reinforcing by filling the prevailing economic vacuum existing in communities whilst bridging the energy supply gap which is common in many communities across the Niger Delta. Interviews with some key stakeholders involved in the participatory workshop reveal that it is estimated that more than half of the stolen crude is sold internationally, and the remaining is retained to maintain the local refining business. According to (Collier & Hoeffler, 2005) oil bunkering is a lucrative business in Nigeria, with a complete demand and supply chain. A network of actors (foreign oil traders, shippers, bankers, refiners, politicians, and security officials accused of complicity) has emerged to sustain the activity with several thousand barrels of oil lost daily and estimated $1billion dollars lost annually. This illicit business continuous to exist because of the demand and supply in both local and international market. The non-state actor phenomena have become a vicious circle and by filling the employment gap in communities that were 'bioeconomically' driven, these activities maintain a positive feedback. Youth unemployment and restiveness is part of the problem in the Niger delta. Lack of dignified income results in vandalism as a way to protest or gain easy cash either by siphoning crude for sale or through employment for the clean-up of oil spill by clean-up contractors. An interview with a local farmer revealed a deep sense of resentment due to the unmitigated consequences of extractive activity in the community and region at large. In his response "I wish the oil will dry up so we can go back to our original occupation". "We only catch fish after toiling for a long time and our crops do not produce good yield anymore: this is not how it used be". The conventional economic reasoning that natural resource wealth was originally construed as key to economic growth and development is a paradox in the region considering that some of the policy instruments formulated to manage mineral extraction and associated rents and taxes are complicit in the marginalisation and disempowerment of indigenous people through elite capture of resource wealth together with environmental degradation and socio-cultural breakdown in the region. The observation reflects the study of (Khoday & Perch, 2012) whilst the realities observed in the ND as well as many other regions of mineral wealth bear the obvious mark of inequality and environmental degradation and lack of transparency in the management of natural resource wealth. For example, there is observed lack of basic infrastructure: roads, schools, filling stations, portable water, hospitals, and suitable housing as observed during the fieldwork. This supports the claim by Cioffi (2007) that less than 20% of the ND is accessible by motorable roads, less than 20% of communities in the region are connected to national electricity grid while 21% have access to health facilities and less than 1% has access to good water. Prior to events of the last decade, the leading causes of oil spill in the Niger Delta was mainly associated to operational discharges/failures however, more recently, vandalism, deliberate or accidental releases from oil tankers, corrosion of ageing pipelines are currently the leading causes (Nwilo & Badejo, 2005). This claim is consistent with the oil spill data (2006-2017) obtained from NOSDRA and analysed in the course of this research. An interview with a community representative reveals a deep dissatisfaction as they allege that the activities of MNOC and the complacency of the government and its lax policies over the years is a "complex self-destructive capitalist policy" that undermines the sustainability of the region. The consequence is the depletion of natural resources and creating environmental resource scarcities for communities that are not fully integrated in the conventional cash economy. Two respondents from different intuitions, NOSDREA and NEITI respectively allege that a "large part of the oil and gas infrastructures would, if subjected to test, fail integrity tests due to age, terrain and climate related factors”. They stated that the regulatory institutions “lack the capacity and resources to carry out independently and adequately their mandates and mostly rely on the companies being regulated for support”. Regulators need to be completely independent of the oil companies in carrying out their mandate to ensure credibility. The study also found that the institutions lacked the capacity in terms of funds, equipment, and technical knowledge to conduct appropriate check on facilities such as lifespan of oil pipelines, time installed and degradation rate and therefore lack valuable important empirical information for regulation. This underscores the need for monitoring to be a statutory requirement in evidence gathering toward policy making. It is also worth noting that interaction with some stakeholders revealed an entrenched mental model with the perception that oil is the source of problems in the region, and that oil companies are the major cause of environmental degradation because oil activities are highly visible and create dramatic local ecological impacts. In fact, there are other anthropogenic and non-anthropogenic drivers in the system such as dredging activities, wetland reclamation, invasive plant species and flooding which are contributing to the environmental pressures of the ND and should be investigated (Adekola & Mitchell, 2011; James et al., 2007). The figure 7.18 is a picture of an invasive species ravaging the creeks in the region. The picture was taken by the researcher during the field work in the ND. The effect of this to ecology and economy of the region has yet to be fully studied.

Figure 7-18 water hyacinth (*Eichhornia crassippes*) infestation of creeks in the Niger Delta

7.7 Validation of the outcome of the participatory process through empirical approaches

7.7.1 Graphical output of Oil Spill data of the ND (2006-2017)

This section presents graphical output of the analysed oil spill data (2006-2017) obtained from NOSDRA. The data demonstrates the respective causes, number of cases and quantity of oil spill in the region which is a symptom of an underlying problem. The analysed data adds to the validity of the research by describing what is actually happening in the region. The graph presented in figure 7.19 shows that sabotage and equipment failure were the leading causes of oil spill in the ND region while the graph shown in figure 7.20 shows that a significant quantity of the oil was lost in the environment with little or no recovery in most of the cases. The graph presented in figure 7.21 shows that sabotage resulted in the largest quantity of oil spilled in the region over the period under investigation. The quantity of oil spilled in this period was about 556899.708bbl in the decade long oil spill data analysed.

Although a statistical test was not conducted due to limited data, the absence of a statistical value does not affect the originality or diminish the important information displayed in the graphical representation.

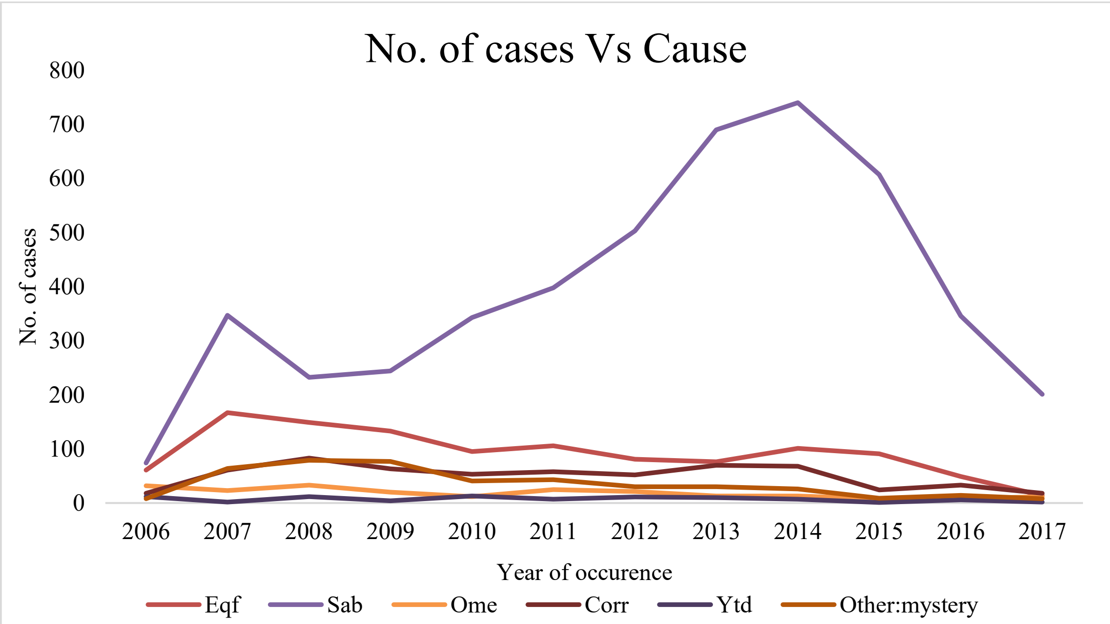

Figure 7-19 Graph showing number of case and causes of oil spill from 2006-2017

Legend: Eqf—Equipment failure

Sab—Sabotage

Ome—Operation maintenance error

Corr—Corrosion

Ytd—Yet to be determined

Other: mystery—Others/unexplained

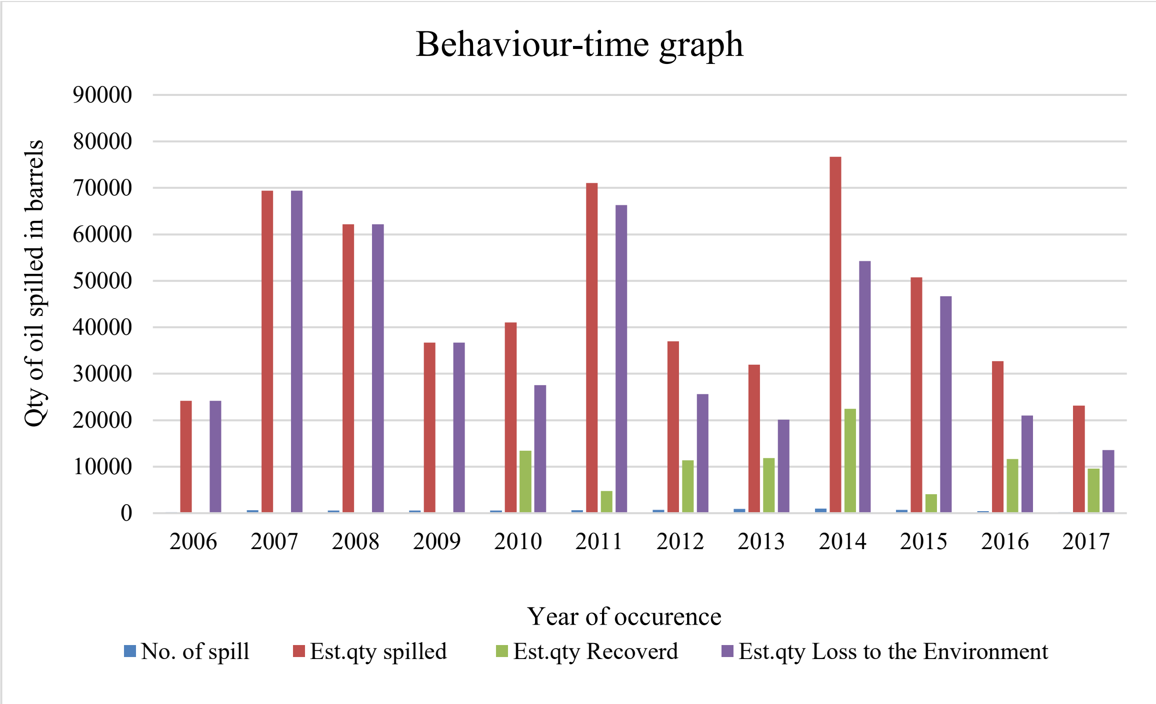

Figure 7-20 Graph showing the number of Oil Spill, quantity spilled and recovered in the ND over a period of 11 Years. Data sourced from (NOSDRA 2017)

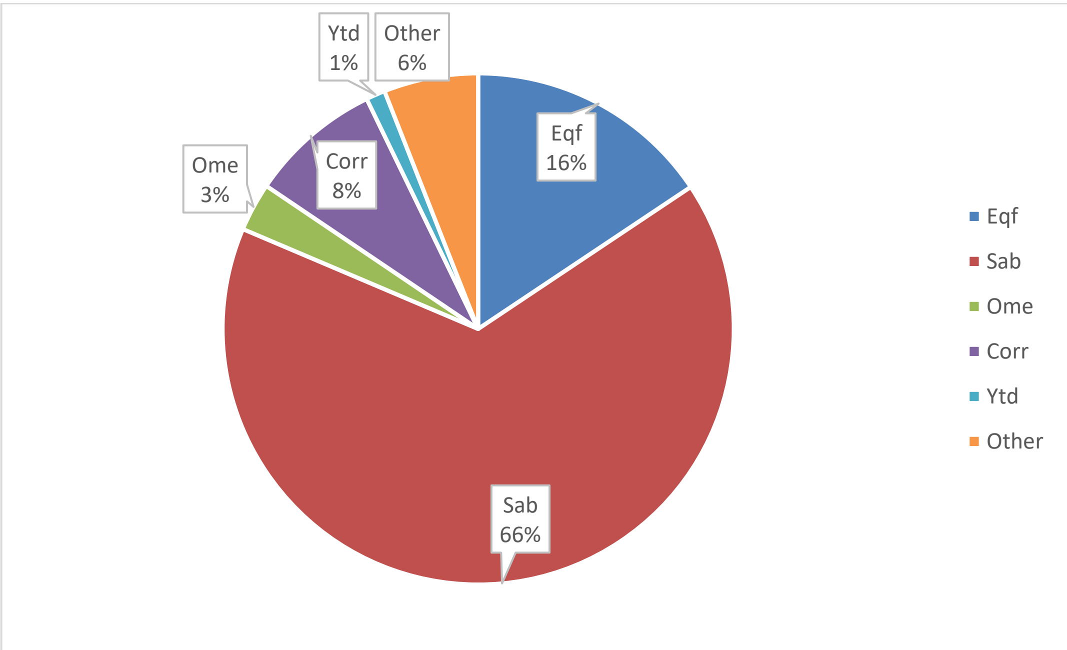

Figure 7-21 A Chart showing percentage the cumulative cause and quantity of oil spilled in years (2006-2017). Data source from (NOSDRA 2017)

7.8 The MAR Framework: A Reflection on its application as a policy making and management support tool

The process of bringing together different stakeholders with conflicting and diverse interests to resolve a natural resource (management) problem that is characteristically heterogenous, socially and analytically complex can be difficult. Therefore, a framework that ensures a structured approach but allows the inclusion of diverse data to support decision-making and management is crucial. Each step in the framework was important to the overall quality of the process; however, there was emphasis on the stakeholder's composition as well as the participatory step/phase since any consensus reached by participants is the metric of assessment and therefore determines the policy response. The framework is a tool for problems structuring, knowledge exchange and for blending of diverse human values into management through consensus building. The collection of diverse data such as historic, biophysical, and environmental data was important in the problem structuring process so as to understand the challenge of the region. The framework provides a structured approach to explore an unstructured problem to generate insight and learning about real world issues through a GMB workshop. In my judgement, when the relationship amongst the stakeholders is poor, it could degenerate into conflict. This was the case in the Niger delta MAR. The framework is a departure from the traditional approaches that are often prescriptive with the assumption that the problem is well defined and understood. Consensus reached through a system based participatory approach is an ideal ethical validation compared to technical and expert knowledge driven approaches because it relies on persuasion and collaboration rather than pressure to synthesise ideas and generate a new knowledge in which all participants can buy-in. Although the 2-day workshop session conducted involved the same group of participants, the outcome/information generated on both days were essentially the same and therefore implies that the idea generated is consistent. In my view, the participatory outcome would have been more robust if all the invited stakeholders participated in the process. Some stakeholders were reluctant to participate however, it is noteworthy that openness is required to be able to collaborate and generate commitment otherwise, people will act in differing purpose or rationalities. This suggests that some views and concepts may have been diminished by the non-participation of some key stakeholders. It is worth noting that despite the shortcoming in the process, lessons were learned, and the framework can serve as a tool with a potential to improve communication amongst stakeholders and ensure a holistic approach to environmental decision making. The framework can benefit from being tested in other MARs which can improve its practicability as lessons are learned. A participatory framework backed by data analysis, interviews and site visit is a robust approach to addressing the persistent natural resource problem in a MAR in which divergent views on management, jurisdictional overlaps exist and where traditional approaches have been ineffective. Overall, the GMB workshop was well received by the stakeholders and participants expressed interest on the final findings of the research.

7.9 Discussion

The participatory process was aimed at gaining better understanding of the problem by understanding the whole system so as to support interventions. Applying the framework in the research to address the complex issues of MARs is based on its holistic approach. The framework provides a structure for different data collection for the purpose of building a problem profile of the MAR, engagement of stakeholders for variable elicitation and consensus-building through a participatory process and validation through interviews, field observation and quantitative data. The goal of systems interventions is to make people aware and to bridge the knowledge gap by providing information and creating consensus that could generate commitment and potentially change people's behaviour and consequently generate a system change. Although this study was focused on investigating the application of systems thinking in the generic management of MARs, its contextualisation to a case study was an important step toward understanding the overarching and hitherto unresolvable problem of the Niger Delta MAR. Andersen et al. (1997) pointed out that the absence of systematic conceptual model to guide researchers on what variables to include or discard limits the comparability of case study group model building, however, the facilitated group modelling process allows participants/stakeholders to gain insight into the structure and behaviour of the system which can lead to system improvement. By focusing on the problem, participants were more open to interacting and suggesting practical solutions and to discussing the trade-offs the decisions reached could give rise to. This is in line with Yin (1989) who claims that cases are suited to hypothesis generation but not to meticulously test them. It however shows that GMB is a practical concept that can be engaged as a participatory approach to explore group dynamics and understand the interactions in a MAR in order to support management. Despite best efforts there are some limitations and research constraints that could have limited the quality of the process such as no clear decision rules on how consensus can be reached, however, this was obviated through a voting process. Since GMB is a combination of participatory process and system dynamics which leads to development of causal loop diagrams to show interactions. Introduction of causal loop diagrams helped to improve the overall quality of the process as a visualization technique. It is worth noting that the outcome of the participatory process as shown in table 7.9, 7.10 and 7.12 provides insight into the problem and offers practical clues to solving some of the challenges in the region.

The interview session was key to understanding many of the institutional challenges and problems of some organisations that have a stake in the region. It also provided an opportunity to obtain information from local people that shaped understanding of the externalities and the multidimensional relationship between environmental damage and the ecosystem services including direct local impacts such as the effect on agricultural productivity, human and ecosystem health, livelihood destruction, civic unrest, and conflicts in communities.

It is also noteworthy that environmental and socio-economic impact of oil and gas extraction in communities, elite capture of resource wealth and deliberate neglect of host communities hinders communities from capturing resource benefits. This stymies progress toward sustainable development from exploitation of natural resource. This asymmetrical relationship promotes the emergence of an illicit oil economy with non-state actor participation; a prerogative of the state *de jure*. Although economic exploitation of minerals and energy resources generates a huge amount of wealth, it has had environmental and social consequences and their development has not delivered sustainable wealth and prosperity to many regions where extraction takes place. For example, across many of the communities in the ND region, the main source of water is the River/Creeks while water bought from towns in plastic sachets serves as a source of drinking water of acceptable quality. Many of the communities are off electricity grid while the main source of energy is biomass (firewood). This is a sharp contrast from the sustainable development goal 6 and 7 which promotes clean water, affordable and clean energy respectively. Some members of the community that were interviewed during the field work gave anecdotal information regarding the impact of extractive activities including a decrease in the quality of agricultural yield which is consistent with the study (Lawanson et al., 1983; Odjugo and Osemwenkhae 2009). This conflicts with the sustainable development goal 15 which promote sustainable use of terrestrial ecosystems, and prevention of land degradation. There has been a decrease in productive land available for farming due to activities of multinational oil companies (Agbagwa & Ndukwu, 2014) and illegal refining activities while most of the communities that thrived on wild fishing have resorted to fish farming because of the low catch resulting from contamination of fishing waters arising from incessant oil spills. This contradicts the goal 14 that promotes the conservation and sustainable use of the oceans, seas, and marine resources. Fish farming, especially commercial fish farming, is contributing to the destruction and degradation of mangroves as most of the farms are sited near the mangrove in order to have constant provision of the brackish water required to grow most of the fish species. The full impact of this new and growing trend has yet to be fully studied especially implications of this for biodiversity.

Considering the rate of environmental degradation in the region, it would be a conceptual mistake to assume that the quality of life of local populations can be improved if the environment which provides the resources, they depend upon is not preserved. This is underscored in paragraph 4.4 of the revised Nigerian National Policy on the Environment 1999: "economic development has not been sustainable partly because biological resources are improperly managed. Manifested by the misuse of biodiversity, the underestimation of the benefits of biological conservation, the non-inclusion of the full cost of biodiversity losses in economic accounting". Paragraph 4.14 of the policy went further, underscoring the need to adopt sustainable strategies for the exploitation of oil and gas resource in the region (Federal Environmntal Protection Agency (FEPA), 1999). This is a stark acknowledgement of the unsustainable extractive operations in the region. The ND communities have an environmentally linked economy; therefore, environmental degradation that leads to collapse of fisheries or agricultural land will have direct and indirect economic effect such as loss of livelihood which results in unemployment and poverty and consequent social problems in the region. This is consistent with study conducted by (Cushing, Morello-Frosch, Wander, & Pastor, 2015) who linked economic inequality with environmental degradation. The Brundtland report (World Commission on Environment and Development 1987) in its pioneer work demonstrates a nexus between natural resources management and exploitation, the state of the environment and poverty. The report was strengthened by the Millennium Ecosystem Assessment report (MEA 2005) whose findings are extensively consistent with the Brundtland report. The paradox is that the mineral assets beneath the ground in the region have not led to above-the-ground transformative investment, consequently provoking issues of sustainability of the region.

The oil spill data analysed shows a huge quantity of oil (5568900bbl) spilled in the period under consideration in comparison, is twice the volume of the 1989 infamous Exxon Valdez oil spill of which approximately 11 million US gallons (260,000 bbl.) which was lost in the environment and considered as one of the most devastating human-caused environmental disasters. In the decade long oil spill, which is still on-going, only about one-fifth of the spilled oil was recovered while much remains in the environment with various ecological consequences. The poor state of the oil and gas infrastructures and incessant equipment failure which is compounded by oil theft leads to persistent oil spill in the environment (on land, inland waters, and coastal/offshore water) and presents a potential infrastructural hazard with risk implications to human and ecosystem health. The infrastructure is encumbered by age and further undermined by economic saboteurs who run illicit economy sustained by continuous vandalisation of oil and gas facilities These activities constitute stressors and create ecological risk through the release of contaminants into the environment as well as habitat destruction. The output of the chart presented in figure 7.21 shows that sabotage accounted for more than 60% of the cause of oil spill in the region followed by equipment failure (16%) and corrosion (8%). This finding is consistent with the study (Nwilo & Badejo, 2005; Onuoha, 2008). Aside from the environmental problems resulting from "bunkering" (sabotage/theft) and vandalisation of oil and gas pipelines, these activities constitute a serious national threat. Considering that these resources and facilities are strategic national assets in terms of national security, some of the attacks can be viewed as energy terrorism given that it threatens the economic security of the state. According to (Onuoha, 2008), bunkering occurs at two scales: small scale operations (local level) and large scale (highly organised by syndicates and cartels). The large-scale accounts for most of the stolen oil which is sold internationally. The local operation supplies the local artisanal refining which fulfils two functions: it fills employment gaps caused by the absence of meaningful employment from mainstream sources of livelihood, and it provides refined fuel to communities and local black-market dealership that is needed due to unavailability and acute shortages. The oil spill data presented is an important piece of information and serves to provide empirical information on the environmental and socio-economic implication of the activities in the region.

In conclusion, the framework was applied here in a step-wise approach (from step 1 to step 8) as an interactive tool for generating information, exchange of viewpoints and reaching of consensus relevant in decision making. By undertaking a participatory approach, the mental models of participants/stakeholders were revealed through a collaborative process to help understand the dynamics of interaction relating to mineral extraction and associated consequences. It is a bottom-up process and allows for representation of the system at base-level processes. Stakeholder involvement is critical for making environmental management decisions because many of the observed environmental problems have underlying socio-political overtones. The study strove to involve all relevant stakeholders; however, it did not take the full breadth of stakeholders into consideration during the research. For example, the participatory workshop was designed to accommodate all identified relevant stakeholders however, those from communities and non-governmental organisations could not participate because of logistical and resource constraints; however, the researcher was able to interact with these group of stakeholders through dialogue interviews during the reconnaissance visit in their communities. This could be a drawback in terms of the underrepresentation of marginalized stakeholders. The participation of all identified relevant stakeholders would enhance the inclusiveness and diversity, however, this has attendant problem of increasing the difficulty in arriving at a consensus. Also, invitation to some oil companies to participate did not receive a good response and one could allege that they were not willing to collaborate. It is common knowledge that oil companies in the ND view with suspicion such activities and see nonparticipation as a way to protect their interests. The role of the stakeholder group is to be willing to collaborate and when this is not happening, it could stifle the progress of the group. In my view, the systems thinking approach to problem conceptualisation, based on participant's mental models could fundamentally change the understanding of environmental problem. The framework is a holistic and adaptive tool that can be applied in policy making and management based on its inclusive approach. As a tool for information exchange, it creates potential for optimal policy formulation and intervention because of its consensus underpinning.

Chapter 8

… many mineral active regions have witnessed a violation of the sustainability principles and epitomise a conformance to the laws of classical thermodynamics in which energy and matter which are neither created nor destroyed are withdrawn and transformed to a different form (to a different region to stimulate and produce more complex social and economic organisation) with accelerated systems entropy in source region as exemplified in the socio-environmental liabilities and underdevelopment (Bunker, 1985).

8 Overall Discussion

8.1 Mineral Resource Active Regions: Definition, and potential of re-assessing them from a systems perspective

The first objective in this thesis was to investigate the complexity of mineral resource active regions and to evaluate the potential of re-assessing them from a systems perspective. In reality, problems do not present themselves in a structured form, therefore, defining and understanding of the problem was key to the problem-solving process. Mineral active regions are complex. Complexity in this context is underpinned by their heterogenous components (physical, biological, technical, human) and diversity of relationships (physical, ecological, infrastructural, social, economic, political) and considers multiple actors, perspectives, and conflicting interest. This objective was accomplished by reviewing regions that have subsoil resources with historical production and ongoing active extraction including associated problems. It was found that management of these resources and their host regions has been a challenge to the trustees and clients of mineral assets resulting in sustainability problems characterised by economic, social, and ecological drawbacks of these mineral hosting regions. This thesis in an attempt to improve the management of MARs expounded the work of (Doloreux et al., 2008; Franks et al., 2013; Young & Matthews, 2007) on "resource regions" by bringing definitional clarity through the introduction of the term "mineral active region". To facilitate the comprehension of MARs and the challenge of management, the traditional management approach which is the practise of many governments, regulators and resource managers was compared to an alternative systems-based management approach that is holistic in its modus operandi to show the weaknesses and the opportunities the two approaches present. In my view, to achieve a sustainable MAR, resource regimes must shift from reductionist rent-based to a holistic interest-based approach that is focused on ecological integrity, sustainable mineral extraction, community rights, redistributive equity, and futurity. In an attempt to represent the concept of MARs, a conceptual model with defined systems concepts was developed following a literature review. The conceptual model shows the components of a MAR which interacts either expressly or indirectly to create a management problem. To realise the research objective and overall research aim, the system approach was proposed which involves thinking, collection of data, integration of stakeholders' mental models and communication. The system thinking through its inclusive approach can offer insight into systems interactions of environmental and natural resource challenges that characterise many MARs.

8.2 Systems decision-making approaches and methodologies: Potential application to MAR challenges

Research design and methodology is an important component of research and serves as the fulcrum of every sound research. Bearing in mind that environmental and resource management is underpinned by decision making, several tools that aid decision-making was reviewed in order to ensure objective selection of a suitable research methodology. Some of the decision making, and management tools employed in environmental research that was reviewed to demonstrate their suitability in environmental decision making as it applies to MAR includes Stakeholder Analysis (SA), Drivers–Pressure–State–Impact–Response (DPSIR), Systems Thinking (ST), and Multi-Criteria Decision Analysis (MCDA). Although these approaches are useful, their suitability in the research context is limited bearing in mind that research questions and aim are the overarching factors that influences a researchers' choice of a method. For example, SA approach is best applied to identify stakeholders, their interest as well as power differentials, however, the process was found to be best suited when the problem or policy issue is known, and short-term intervention is required (Brugha & Varvasovszky, 2000). For a MAR, part of the solution finding is to understand what the real problem is due to different interest conflict. People's perception and understanding of things differ even when describing the same problematic issue and there is no clear definition of what the problem is, the application of SA becomes challenging and limited.

The DPSIR framework is a practical tool for demonstrating and connecting the key relationship between society and the environment in a simplistic way and which allows policy or decision makers to understand easily environmental problems and their links that could be obscured by complex scientific representation, however, its deterministic position is a major criticism for being unable to capture several underlying interactions without losing its simplicity as a communication and decision making tool and therefore not appropriate for dealing with complex socio-ecological problems as found in MARs.

MCDA has been employed in environmental and sustainability decision making to address diverse stakeholders' interests. It provides an easily communicable outcome through empirical quantification of decision values. In my view, a drawback to this approach is the reduction of a complex socio-economic and environmental problem to quantitative metrics and the reliance on "experts" to assign weights which can introduce bias that can affect the overall quality of the decision. MCDA is best applied when the problem is known, and decision goals are established based on the interest of stakeholders. For a MAR, the problem is complex and not clear. Therefore, MCDA would not be the appropriate approach to address the research problem.

The systems approach is an engagement tool or framework to facilitate learning and understanding of interactions through an organic way of thinking with focus on the whole system through an inclusive and participatory approach that incorporates different data types, diverse stakeholders' perspectives into decisions making. It is useful in deconstructing complex systems problem and fostering of knowledge through consensus building across disciplinary boundaries represented by a broad range of stakeholders. The problem of MAR is unstructured, broad, and cross-sectoral and characterised by a conflict of interest which results in complexity. System thinking offers the potential to understand and manage the complex interaction in a MAR based on inclusive, participatory, and holistic approach. Therefore, systems thinking was chosen as the research approach because it has the potential to address the problem of MARs based on holistic approach.

8.3 The participatory framework as a potential tool to facilitate the management of MARs

One of the deliverables of this thesis is the participatory framework developed to support policy making and management of MARs through a stakeholder driven approach. The framework is an eight-step process with a participatory rationale. The framework integrates information from different disciplinary domains in addition to the engagement of stakeholders to explore the problem, collaborate, exchange knowledge, build consensus and commitment in order to solve the complex problem of MARs. The framework was defined on the basis of "current state" and "desired state". The current state is the default systems state in which interaction produce unsustainable outcomes such as (environmental degradation, poverty, and social problems) while the desired state is that in which the systems is sustainable. Bearing in mind that a system is a product of its interaction, the task lies on actions and steps that can be taken to ensure the desired state is achieved. The overarching objective is to support the management of MARs through knowledge development with minimal bias, transparency, and collaboration. The framework operationalises the constructs of sustainability into a tool for environmental management. It was designed to provide a quick guide on the type of information and steps required to engage a complex socio-ecological problem found in MARs and has the potential to reduce the time consuming and expensive process of traditional participatory concepts. Therefore, engagement of stakeholders, elicitation of variables and reaching of consensus and policy recommendation is expedited during the participatory model building sessions provided by the framework. The framework developed in this study is a structured template to gain evidence that can support management and policy making and overcome the opacity and cumbersomeness presented by some approaches that rely on technical environmental decision modelling needing expert knowledge in application or interpretation. Its stakeholder and consensus underpinning allow for the incorporation of participants' opinions including opposing viewpoints to reach the best decision which is an ideal validation of the process. Although the study considered the social and economic components of the MAR, it focused majorly on ecological impacts. This is due to a downward trend in the ecological stability of many MARs considering that ecological impact is a key lens through which extractive activities have been viewed recently in an increasingly connected and globalised world in order to account for externalities associated with mineral extraction.

8.4 Application of the MAR Framework to a Case Study

Although every region is a special case, the framework was applied in the ND which is as an exemplar of a MAR whose environmental system is functionally and structurally complex — a nexus of terrestrial and aquatic systems and buried geological treasure. Utilising the framework as a structured template to address the unstructured and complex problem observed in MARs, the participatory approach was applied to a test case — the Niger delta, which resulted in learning by participation, communication, and exchange of viewpoints to improve on the knowledge of the system. This started with defining the scale and boundary of the research by delimiting the research focus and the environmental problem spatially and temporally — exploring the history of oil exploration in the Niger Delta and how the colonial search and prospecting of oil conflicted with the customary laws which served to regulate and protect the region and its environment. The environmental characteristics of the ND ecoregion was highlighted to demonstrate its unique features and the implication of oil and gas extraction activities on the human and ecosystem health of the region. For example, extraction activities involve several activities (dynamiting and geological excavations, clearing of habitats for construction of oil and gas infrastructure such as the pipelines, flow station, as well as produced water which is a cocktail or heavy metals, radioactive materials and hydrocarbons that ends up in the environment) that has the potential to upset the ecological balance of the region with social and economic consequences for communities. Secondary data was extracted and analysed to show behaviour-over time trends whilst the underlying information gives an indication of what has been happening in the region over the years and constitute a reference for the environmental impact of extractive activities in the region. The analysed data shows that decades of oil spill and gas flare in several communities in the region has led to the destruction of ecosystems as well associated goods and services provided by such ecosystems. Amongst many examples is the Bodo community in Ogoni Land in the ND in which unabated oil spill that lasted for over two months changed the ecological character of the region with decline in the floral and faunal species, death of mangroves and eventual collapse of notable fisheries within Bodo Creek (Cushing et al., 2015; Pegg & Zabbey, 2013). The cause was attributed mainly to technical failures, corrosion from poorly maintained oil and gas infrastructure and sabotage. The analysed time series graph for gas flare over a period of four decades (**see figure 7.10**) shows a progressive increase in the amount of gas flared over the period until the 'partial' enforcement of the Associated Gas Reinjection Act (**see table 7.3**) in the early 2000 which prior to this time had almost all produced gas flared (estimated around 75%) and with only 12% reinjection to enhance oil recovery because of lack of gas utilization infrastructure in Nigeria. Oil producing companies in the Nigeria jointly criticised the application and enforcement of zero gas flares policy as technically infeasible. However, enforcement in the recent years led to increased utilization of gas with a corresponding reduction in the amount flared. However, despite the progress made, the region is inundated with large volume of flared and vented gases at high environmental, health and socio-economic cost. The enforcement of the Associated Gas Reinjection Act shows that policy making and enforcement and two inseparable factors that could change the dynamics of events. It must be stressed that political will finds expression in more than policy statements but through enforcements. This underscores the essence of resource governance as a step in the MAR framework. The government in a bid to addressing the environmental and socio-economic problem occasioned by oil and gas extraction in the region has pursued resource governance in the region through decrees (during military regime) and parliamentary acts, enacted laws and also signatory to major international treaties and conventions on the environment. In my opinion, the execution of the policies and programs including enforcement through regulation (institutional and legal framework), economic instruments (trade, subsidies, markets, taxes) and information (empowerment of stakeholders) of the relevant domestic legislation, international treaties, and conventions has been ineffective in addressing the problem because there is no tool or structured template to guide government departments responsible for the execution and enforcement of the problem. Also, a problem identified with some of the government regulatory institution is the problem of continuity in public service. That is when people are transferred, promoted, or retired or when new administrations come into power, the process is abandoned or slowly executed.

The fifth step in the framework involves the identification of relevant stakeholders in the MAR in which key stakeholders were identified through a literature review and using the snow-balling referral pattern other relevant stakeholders were identified. The framework for management of MARs developed in this study is a tool with generic functionality that has the potential to operationalise actions that can lead to improvement of systems conditions and ensure the sustainability of MARs when applied as adaptive management tool. The framework can support various data especially in the problem structuring aspects which obviates the need for specialised data in a situation of paucity of data so as to address information gap that obscures environmental policy making. The framework advocates for democratic participatory decision-making processes because it is empowering compared to top-down practices that characterise traditional management represented by expert and technical driven approaches.

8.5 The participatory stakeholder engagement: group model building workshop and interviews

The application of the participatory framework was aimed at generating information by improving the decision-making process through an inclusive bottom-up stakeholder driven approach. The process enables researchers to understand gaps in knowledge, vested interests and ensure development of a robust environmental policy that is not only driven by science but also by social, economic, and political priorities. The participatory process was designed to be democratic starting with stakeholder identification through a snowballing approach to decision reached through consensus by voting. Through democratic deliberation, the civic populace and stakeholders are armed with improved and consensus knowledge to deal with the complex environmental and sustainability problems (Niemeyer, 2004) whilst enfranchising the environment and strengthening social backing and local buy-in. The participatory processes recognises the legitimate views of all participants and create room for credibility through minimisation of bias and improvement in transparency which can restore/improve public trust and has the potential to engender change and consequently influence people who are part of the system by empowering them to know the consequences of their actions/inactions in the system (Beierle & Cayford, 2002; Van Den Hove, 2000). The participatory systems approach applied in the study investigated the structural relationships that underlie unsustainable trends observed in the ND-MAR and captured divergent views. It provided an opportunity to elicit the mental model of participants regarding their view and conception of the problem of the region and to understand their interest and desired systems state. An example is the differing conception of the problem of the region during the workshop by participants in which some focused on the observed physical manifestation of the problem of the region while others viewed it through a number of socio-economic and environmental drivers underpinned by poor resource governance regime. The process allowed the generation of new hypotheses with broader explanatory capacity of activities in the region than the traditional discipline-based approach that places emphasis on economic rationality, regulatory standards and meeting policy targets that are often not met. From my perspective, the process has the potential to deliver a practical and sustainable outcome since the process allow those who are affected by a decision or who have a stake on an issue to participate directly in the decision-making process. An important outcome of the application of the participatory process in the ND was the identification of drivers and motivation behind some problematic and policy-resistant issues such as interdiction and vandalising of oil assets in the region in which strategic national assets are vandalised to maintain an illicit economy with a patronage network. Such information can among others aid in development of policy and programs to address these problem drivers from the source/root.

The interviews even though were not part of the initial research designed, was very useful in discussing the general research findings especially with regards to institutional challenges and supports information from relevant literature and previous findings. The interviews conducted with stakeholders after the participatory workshop reveal some institutional challenges such as paucity of funds to execute programs and projects, lack of sufficient technical knowledge and skilled workforce, weak legal framework, agency bureaucracy and regulatory overlap.

The oil spill data analysed supports the study and demonstrates underlying environmental cost of extractive activities in the region as well as socio-political concerns in the region. In the year 2014/2015 as shown in figure 7.19 and 7.20, the increase in the number of cases/incidences of oil spill can be associated with the election conducted in that period. The presidential election in 2014/15 was between a southerner from the ND and the Northern person which was the first time a person from the ND had aspired to occupy the highest position in Nigeria. The destruction of oil facilities was a political statement from 'men in the creek' meant to ensure the emergence of a ND person otherwise the government should prepare to deal with disruption in oil extraction activities which consequently impacts on the economy since the country's economy is oil driven and only extracted from the ND region. This further highlight how election cycles can influence the geopolitical condition of a MAR.

It is noteworthy that environmental problems do not just disappear, we have to deal with them and there is no straightforward solution. The framework has demonstrated to be a practical tool in policy making and management. The operationalisation of the systems approach through a participatory framework is a potential approach to managing the complex and omnipresent socio-economic and environmental cost of extraction in a MAR.

8.6 General Discussion

Complex socio-ecological and economic problems such as those seen in MARs cannot be analysed with disciplinary approaches alone. Socio-ecological interactions are typically complex and models to predict with certainty the immediate or long-term environmental degradation and socio-economic stability are unfeasible. Thus, scientific knowledge is not sufficient because even when the effects are predictable, the lack of absoluteness in defining all the factors and variables involved means that scientific or technical solutions to environmental problems are limited (Stave, 2002; Van Den Hove, 2000). Policy-makers are getting more aware that scientific knowledge is not enough but requires knowledge exchange through diverse representation and engagement of stakeholders. Moreover, technical tools used in the prediction of environmental problems often rely on proxies and assumptions including uncertainties which are dealt with by expert interpretation so that non-technical policymakers find it difficult to use them (European Environment Agency, 2011). It is important to note that expert knowledge is crucial in environmental policy making but the absolute reliance on experts for solution in complex socio-ecological problems such as those observed in MARs would be a bit too optimistic. Policy-makers nowadays strongly advocate for interdisciplinary participatory knowledge development to complement technical solutions for environmental problems. Based on the interdisciplinary perspective of the systems approach, it is considered an effective approach for policy development especially when a research problem is messy and the research objective is problematic and difficult to define (Antunes et al., 2006).

It has been demonstrated in this thesis, that ecological, social, and economic condition of many communities in mineral active regions is diminished through loss of ecosystem services when landscapes are changed, pristine environments are damaged, and biodiversity is depleted. Findings from the application of the framework in the ND region reveals a progressive underinvestment and underdevelopment of the region through unsustainable extractive regime (cite) — phenomenon consistent with the resource curse paradigm (Gylfason 2000; Cockx & Francken 2016). The ND context and findings are consistent with Bunker's assertion (Bunker, 1985) which argued that resource-exporting regions lose values in their physical environment through ecological disruption with the depletion of energy and material values of the region whilst the regions where they are exported, transformed, and consumed gain value, economic acceleration and become more complex in social organisation. The situation demonstrates how communities which thrived sustainably on ecosystem goods and services while off the cash economy are impoverished by unsustainable extractive activities and ineffective resource governance regimes. In this study, it has been demonstrated that MAR is not an isolated system. It is influenced by drivers external to the system (region). For example, economic globalisation, sustainability, climate change, and ecosystem degradation are stretching across these geographically remote regions of mineral wealth and consequently shaping the extractive industry landscape while at local levels environmental, economic, and socio-political factors are shaping arguments on regional futures and sustainability. Conflicts, environmental degradation, corruption are some of the social complexities and emergent consequence of the interaction that happens in a MAR. Through the participatory process presented in the framework, problem variables were elicited whilst linking the consequences of mineral extraction (an economic activity) with negative environmental consequences such as loss of biodiversity and deterioration of ecological health—a negative feedback.

Robust and effective policy making is founded on strong political will and backing. It is generally acknowledged that any well-crafted and painstakingly designed environmental policy will be of no impact if there is lack of political uptake and enforcement. Therefore, necessary institutional machinery for enforcement and timely interventions and adequate governance structures must be given priority as this is found to be lacking in the region as highlighted in **table 7.6.** According to (Vedung, 1998) environmental policy instruments can be considered in line with the degree of authoritative force supporting it and could be classed broadly in the form of regulation, economic instruments and information. Following the information provided by this study, the ND region reflects to some degree policy failure/resistance because despite several legislation and policy instruments developed to manage activities in the region, in practice this has clearly not achieved the required progress considering that some environmental unfriendly extractive activities that have been outlawed are still on-going. The reasons for the failure as demonstrated in this research are consistent with the findings of (Howes et al., 2017) who assert that "economic, social, environmental, political, legal, technical, policy conflict, incentive failures, agency bureaucracy, limited agency competence, paucity of administrative resources to support policy implementation, and communication failure" are responsible. As demonstrated in the study, environmental regulations in some of these regions, for example the ND, are usually enacted with great expectations and assigned multiple jurisdictional oversight, only to go unenforced through bureaucratisation of agency functionaries. To reduce the associated institutional complexity, management arrangement should be reformed to eliminate multiplicity of agencies' functions and improve interagency cooperation and ensure efficiency and effectiveness on the discharge of duties. For instance, economic sanctions designed to address unsustainable extractive activities in the ND region was poorly designed and extractive companies exploit the weakness to continue unsustainable extractive practices. An example is in the payment of fine for gas flare and compensation for damage caused by oil spill arising from extractive processes or damage from oil infrastructure. The fine on gas flare is little and it is deducted before the remittance of taxes and export earnings to the federal government through the NNPC. The oil companies exploit the provision of no compensation for oil spill arising from sabotage. Poor communities become the victims and are held responsible for complicity of sabotage and therefore no compensation is paid. These demonstrates that the policies have not deterred the bad extractive practices going on in the ND. These findings further the debate on institutional issues, agency cooperation and public participation in management programs and emphasise the need for a systemic policy intervention that is based on holistic principles as against the reductionist regulatory approach of meeting targets and therefore non-comprehensive at managing environmental complexities. For instance, the lack of institutional embedment of systems thinking and/or lack of operationalisation of the approach results in segmentation and compartmentalisation which reduces complexity by streamlining, but also limits systemic sustainable interventions that is witnessed in the ND. According to (Ascher, 2001) the sustainability of ecosystems and natural resources can be achieved if the complexity created by institutional interests is overcome. Acheson (2006), argues that management is a challenge to institutions of government tasked with the management of natural resources. For example, in developed countries, institutions are staffed with scientists who are largely from urban areas and whose interest is focused on scientific and technical aspects (rational and top-down policy approach), whilst soft factors such as local culture and community involvement are reduced to sheer consultation instead of participation in the policy process due to poor communication or neglect (Acheson 2006). The lack of knowledge of sustainability at community level together with a lack of awareness of how institutional actions could be contributing to sustainability issues results in policies that are devoid of local ecology and therefore could present a problem in implementation and local buy-in. In developing countries such as Nigeria, many of the institutions lack necessary resources and are staffed with scientists and engineers who lack hands-on technical knowledge and are unable to produce empirical reports that would support policy formulation. According to (Coria & Sterner, 2011), this presents a problem to many developing countries and therefore suggested that informational, legal, or market-based instruments could be the preferred options. This is especially true where policy mandates are based on quantitative limits (e.g. gas flares or emissions in the case of the ND Nigeria) and would require empirical justification. The framework therefore serves as a tool for assessing the problem of a MAR by gathering evidence and integration of multidisciplinary data/information to supplement for institutional lack of robust monitoring or experimental data for the empirical justification of regulations and enforcement.

In view of the foregoing, increased funding as well as strengthening of legal frameworks will improve the management regime. Some studies indicate that resource accounting measures including compensation in many mineral active regions is a limitation to the management regime and incentivise environmental degradation because of poor policy design, execution, and enforcement. This is because the accounting measures do not evolve and adapt with the pace of change in the system and are therefore inadequate. After the comparison between the official and OPTS compensation rate for damages from oil and gas activities, it can be argued that the compensation guideline and rates do not reflect market realities and therefore inadequate. Well-designed environmental accounts should overcome the limitations of the current deficient and market-centric accounting system by incorporating non-market economic activities, see (Adekola et al., 2015). From my perspective, to achieve sustainable development in MARs, policy making should seek to ensure and enforce the internalisation of the degradation of environmental assets through taxes to compensate for the loss of environmental capital whilst instrumenting policies through which wealth can be transmitted to future generations to ensure intergenerational equity through strengthening of institutions to be independent of political interest and manipulations, and it should also ensure adequate funding in addition to competent staff. Practicable examples exist; for example, the mineral active region of Norway (Alfsen & Greaker, 2007; Holden, 2013). The Norwegian authorities and decision makers understood the impact of oil to the economy and the environment that they sought to develop the resources to benefit the society, including future generations through parliamentary adoption of ten (10) basic principles (see Appendix 1) in 1972 known commonly as the ten oil commandments (Holden, 2013). Emphasis was at regional levels to ensure appropriate economic returns and environmental management including a policy to ensure coexistence of oil and gas with other industries, particularly the fisheries industry.

This study reveals there is significant out flow of energy resources from the ND region without a commensurate inflow of resource benefits to the region whilst the natural resource base declines correspondingly; a pure violation of sustainability principles in a period when rational arguments are built around sustainability. It is therefore essential to ensure the sustainability of one community/region/society does not come at the expense of another. This condition is not exclusive to the case study region, but a pattern found in many MARs around the world (e.g. Cabinda regions of Angola, Orinoco Delta Amacuro of Venezuela). Undoubtedly, to ensure benefits are returned to the community and ensure distributive equity of resource wealth, the principle of derivation built on legitimate consideration in terms of returning a fair percentage of oil/mineral revenue to the oil/mineral producing communities is maintained whilst the government and big businesses must cease stripping communities of economic and political rights — a cause that resulted in the promotion of the free, prior and informed consent (FPIC) as well as UN Declaration on the Rights of Indigenous Peoples, (Mackay, 2004) which reaffirms the right to self-determination. There are no doubts communities want environmental and social impacts lessened whilst economic benefits maximised through fair modification of the resource allocation formula. Therefore, to ensure a sustainable mineral active region, consideration must be given to the need for communities to capture and enjoy long-term benefits from mineral wealth extracted, be empowered to protect their local environments and maintain well-being and cultural values, and be able to shape and influence issues that affect their future in the context of mineral development and associated sustainability issues — as highlighted in the sustainable development goals. It is worth noting that global demand for mineral resources would, unchecked, continue to have double-edged effect through economic gains and ecological disruption respectively. Therefore, a holistic management approach is required to address the broad range of socio-economic and environmental problems in a MAR in order to steer such regions toward the sustainable development paths. This study contributes to the environmental policy regime of MARs and by providing a framework to elucidate objective and factual realities about the states of affairs, it empowers policy makers and managers with a tool that can support decision-making and management. Although it is not a deterministic tool, the prescriptive application of the framework enables policy makers and resource/environmental management personnel the capability to support participatory policy making that can ensure environmental protection and sustainable development.

8.7 Conclusions

Effective management of real-world environmental issues must acknowledge real-world systems complexity and with increasing policy resistance there is need for a systems approach to problem solving. The aim of this research was to develop a participatory systems framework to improve the management of MARs. Conceptual models were developed to represent a system view and establish the components of a MAR which consequently improves our understanding of the system. The participatory systems tool developed in this thesis is to constructively engage stakeholders in a participatory process for understanding of complex environmental problems and support systems intervention. The framework allows the inclusion and exploration of multidisciplinary data to understand the system and engage stakeholders in a participatory process which reduces opacity by integration of different perspectives and value judgements encountered and ensure consensus in decision-making through a collaborative process. Based on literature review better understanding of the problem context was developed which led to a definitional clarity to the research discourse by introducing the term Mineral Active Region (MAR). It was found that complexity, uncertainty, knowledge gap, conflicting interest, and institutional bureaucracy obscure and undermine initiatives that aim to ensure the sustainable development of MARs while considering communities and ecosystems. The participatory systems framework developed was applied in a case-study (the Niger Delta) which provided the opportunity for the engagement of stakeholders to learn, collaborate, build consensus, and generate knowledge/information that can support management and policy making. The outcome of the participatory process reveals some unknown problem drivers in the region, challenges of institutions as well as their implication/consequences to policy and management. Based on the knowledge generated from the study, it is crucial to acknowledge that society's need for mineral and energy resources to provide industrial stocks and meet global energy will continue and its ecological consequences are evident. Therefore, there is need to ensure that economic pursuit through mineral exploitation is integrated with responsible environmental stewardship, social concerns, and effective governance regimes to ensure development is sustainable. It is necessary for governments whose economies are mineral driven to design appropriate methodologies to address the policy challenge that limits management and hinders the sustainable development initiatives. Policy should be adaptive and responsive to the changing dynamics of the system. For example, the study shows that many of the policies including economic policies in the Niger delta MAR are not evolving and not adaptive. Such economic policies/instruments do not encourage markets to reflect the full social and environmental costs of mineral resource extraction while the lack of enforcement of existing regulations is the most important regulatory constraint facing the ND region.

It has been demonstrated in this thesis that the framework is a handy tool to support information exchange, develop new knowledge, partnership and support management through participatory approach that has the potential to address the social and analytical complexity that characterise MARs. The study went beyond the application of systems thinking that has focused more on the philosophy than on practice, especially in sustainability and resource management studies, by developing an actual useable framework to address complex unstructured problems. This is the first study to integrate heterogenous components of complex natural resource systems in stepwise approach to develop a framework in order to understand the problem of MARs. In this thesis, I argue that resource development and environmental stewardship are not mutually exclusive as they can be simultaneously coupled with responsible resource management effort underpinned by robust policy and effective regulation. Effective collaboration between stakeholders will make it possible to identify and explore a range of environmental problems and opportunities, communicate these issues to a wider audience and find innovative solutions that benefits all stakeholders. Since the framework has been applied in the ND, the practicality of the tool and the outcome of the application demonstrates that it has potential for wider application to support decision-making and management across other mineral active regions.

8.8 Recommendations for future work

The framework evolved as an output of the research and its application in this thesis was restricted to a single case study, a validation process by way of deployment to other mineral active regions is key to improving the process and to ensure the framework is robust. Improvement in data gathering, biophysical data (e.g. emissions release, oil pollution, acidification, water quality, GHG emission) and participatory workshops will enable the design of a conceptual dynamic framework and causal loops and then quantifying them and simulating, and testing. Further study should attempt to understand how cultural, geographical, and institutional differences could impact the application of the framework. This will enable the development of a hybrid framework as suggested by (Duggan, 2015) which allows for the incorporation and application of qualitative and quantitative techniques and argues that it provides a more robust worldview to explore socio-ecological problems. Future research will consider translating relevant environmental and socio-economic issues to context specific indicators as a practical valid criterion through which change can be monitored and measure.

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Appendices

Appendix 1:

The Norwegian 10 oil commandments

The parliament (Stortinget) unanimously adopted the following10basic principles in June1972:

i. National supervision and control must be ensured for all operations on the NCS.
ii. Petroleum discoveries must be exploited in a way which makes Norway as independent as possible of others for its supplies of crude oil
iii. New industry will be developed on the basis of petroleum.
iv. The development of an oil industry must take necessary account of existing industrial activities and the protection of nature and the environment.
v. Flaring of exploitable gas on the NCS must not be accepted except during brief periods of testing
vi. Petroleum from the NCS must as a general rule be landed in Norway, except in those cases where socio-political considerations dictate a different solution
vii. The state must become involved at all appropriate levels and contribute to a coordination of Norwegian interests in Norway's petroleum industry as well as the creation of an integrated oil community which sets its sights both nationally and internationally.
viii. A state oil company will be established which can look after the government's commercial interests and pursue appropriate collaboration with domestic and foreign oil interests.
ix. A pattern of activities must be selected north of the 62nd parallel which reflects the special socio-political conditions prevailing in that part of the country
x. Large Norwegian petroleum discoveries could present new tasks for Norway's foreign policy.

Appendix 2:

Research interview questions

- In your view, what is/are the main driver(s) for oil and gas extraction in the Niger Delta? What main factors define the success of extractive companies?

- In your capacity as a staff of (name of organisation), what is your knowledge about environmental problems in the Niger Delta. What has been tried (did it work or not and why) and what can we do or what is left to be done to ensure a sustainable mineral active region.

- In your view, are socio-political, environmental, and economic problems in the Niger Delta isolated issues or they significantly influence the other. If yes, how do they interact with each other?

- Why have host communities in the Niger Delta accused multinational oil companies of causing massive environmental damage?

- How does your agency through oversight functions ensure that compensation is paid to local communities who are negatively affected by the activities of oil and gas production?

- Do you think the pieces of legislation specific for resource and environmental management in the ND region has been effective?

- What is the level of investment in infrastructure and social amenities in the region by agencies of government and corporate organisations?

- What are your views toward ecosystem goods and services in the region?

- What are the legal, institutional, technical barrier to discharging your statutory duties?

- As a stakeholder in the extractive industry, what is your knowledge of the time frame oil and gas facilities (e.g. pipelines) undergo overhaul? In your view, how often should these facilities be overhauled to avoid equipment failure?

- How do you think change in right of ownership of subsoil mineral could change the environment and socio-economic landscape of the region?

- What is your view of the relationship between oil producing companies and host communities?

- In the last 10years, what has been the nature of your crop harvest?

- Where do you fish (rivers or creeks)? In the last 10 year, what has been the nature of your fish catch?

- Mention some of the environmental problems in your communities. How does this affect you?

Appendix 3:

Data of oil spill in the Niger Delta region over the years in time series outlook

Oil spill in the Niger Delta region over the years in time series outlook

Year	No. of Spill	Qty Spilled (in barrels)	Qty Recovered (in barrels)	Qty Loss to the Environment (in barrels)
1976	128	26157.00	7135.00	19021.50
1977	104	32879.25	1703.01	31176.75
1978	154	489294.75	391445.00	97849.75
1979	157	94117.13	63481.20	630635.93
1980	241	600511.02	42416.83	558094.20
1981	238	42722.50	5470.20	37252.30
1982	257	42841.00	2171.40	40669.60
1983	173	48351.30	6355.90	41995.40
1984	151	40209.00	1644.80	38564.20
1985	187	11876.60	1719.30	10157.30
1986	155	12905.00	522.00	12358.00
1987	129	31866.00	25757.00	25757.00
1988	208	9172.00	1955.00	7207.00
1989	228	5956.00	2153.00	3803.00
1990	166	14150.35	2785.96	12057.80
1991	258	108367.01	2785.96	105912.05
1992	378	51187.90	1476.70	49711.20
1993	453	8105.32	2937.08	6632.11
1994	495	35123.71	2335.93	32787.78
1995	417	63677.17	3110.02	60568.15
1996	158	39903.67	1183.81	38719.86
1997	266	74749.52	1243.50	73506.02
1998	133	69338.68	383.50	68955.18
1999	260	28013.72	100.80	27912.92
2000	51	10179.75	0.00	10179.75

Data Sourced from (Uyigue & Agho 2007)

Appendix 4:

Time Series data of produced gas utilised and flared or vented gas in the Niger Delta region

Year	Production (Mm^3)	Utilization (Mm^3)	Flared (Mm^3)
1970	8029	72	7957
1971	12975	185	12790
1972	17122	274	16848
1973	21882	395	21487
1974	27170	394	26776
1975	18656	323	18333
1976	21276	659	20617
1977	21924	972	20952
1978	21306	1866	19440
1979	27619	1546	26073
1980	24551	1647	22904
1981	17113	2951	14162
1982	15382	3442	11940
1983	15192	3244	11948
1984	16255	3438	12817
1985	18569	3723	14846
1986	18739	1822	13917
1987	17085	4794	12291
1988	20253	5516	14737
1989	25053	6323	18730
1990	28163	6343	21820
1991	31588	7000	24588
1992	32464	7058	25406
1993	33444.6	7536.2	25908.4
1994	32793	6577	26216
1995	32980	6910	26070
1996	36970	10150	26820
1997	36754.8	10207	26547.8
1998	36036.6	10886.5	25150.1
1999	35856.4	12664.6	23191.8
2000	47537	21945	25592

2001	57530	29639.7	27890.3
2002	101976.1	26203.4	75772.7
2003	53379	30583	22796
2004	69748	45156	24592
2005	58247	34818	23429
2006	57753.7	39374.8	18376.9
2007	65936.5	43188.4	22748.1
2008	66640.8	48796	17844.8
2009	41534.2	28076.5	13457.2
2010	58006	44506.6	13499.3
2011	55099.1	38898.2	16200.5

Data Sourced from (Uyigue & Agho 2007)

Appendix 5

Data for the graph showing the number of oil spill, quantity spilled and recovered in the ND

Year	No. of spill	Est. qty spilled	Est. qty recovered	Est. qty Loss to the Environment
2006	205	24169.2544		24169.2544
2007	664	69423.5073		69423.5073
2008	588	62170.2032	20	62150.2032
2009	541	36720.3205	28	36692.3205
2010	559	41036.1029	13463.746	27572.3569
2011	637	71064.9603	4762.354	66302.6063
2012	698	36975.3432	11365.918	25609.4252
2013	889	31986.56733	11859.4413	20127.12603
2014	955	76720.5217	22481.2862	54239.2355
2015	740	50777.26722	4069.4231	46707.84412
2016	456	32720.15502	11682.8973	21037.25772
2017	255	23147.35551	9582.0203	13565.33521
		556911.5586	89315.0862	467596.4724

Source: Data sourced from (NOSDRA 2017)

Appendix 6

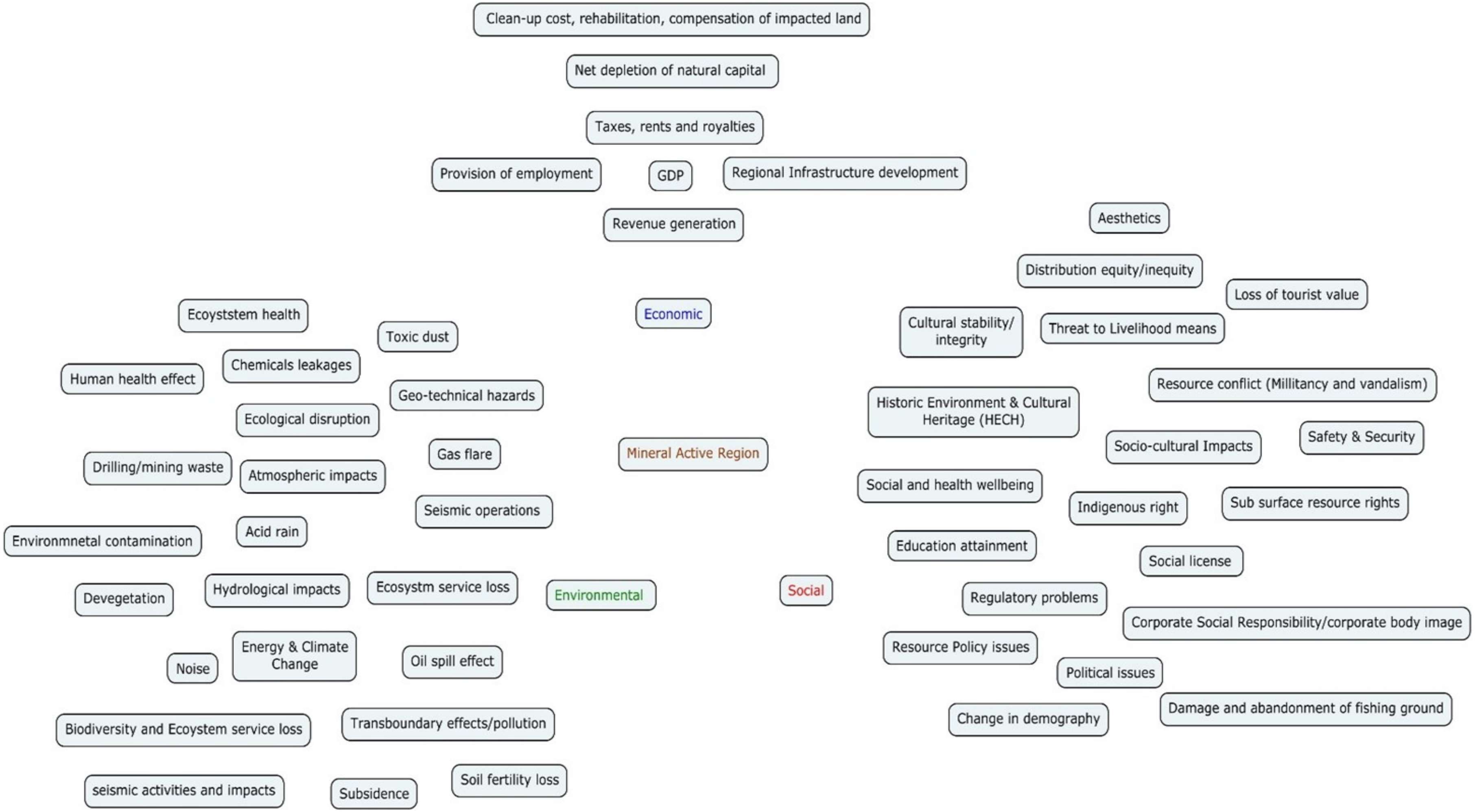
Data for the chart showing in percentage the cumulative cause and quantity of oil spilled in

Cause	No: of cases	Qty Spilled
Eqf	1123	112581.599
Sab	4725	394406.04
Ome	220	2686.9249
Corr	601	31521.2813
Ytd	87	9797.34188
Other	429	5906.52132
	7185	556899.708

Source: Data sourced from (NOSDRA 2017)

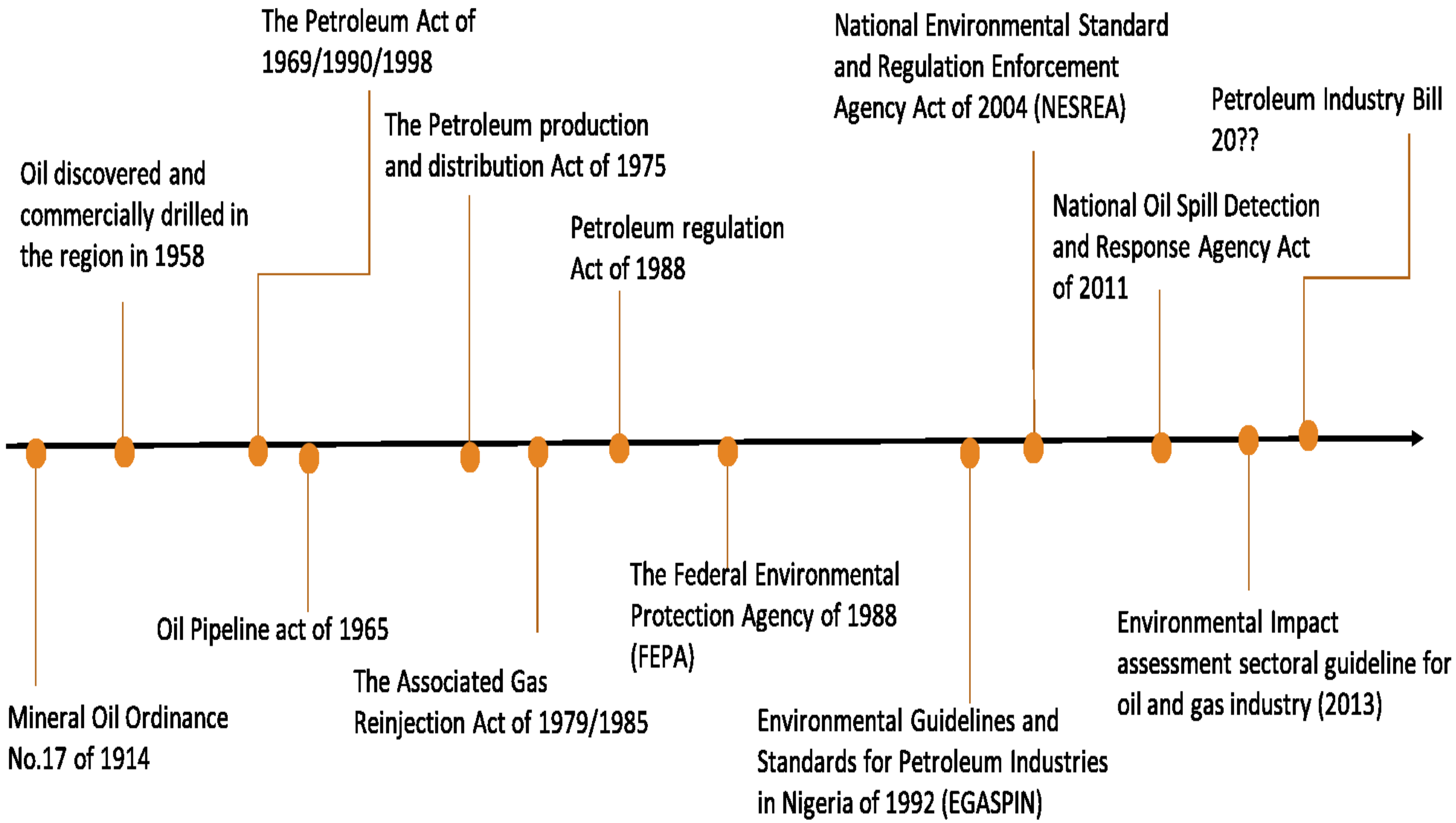
Appendix 7:

A Generic Mind map of some variables observed in MARs



Appendix 8:

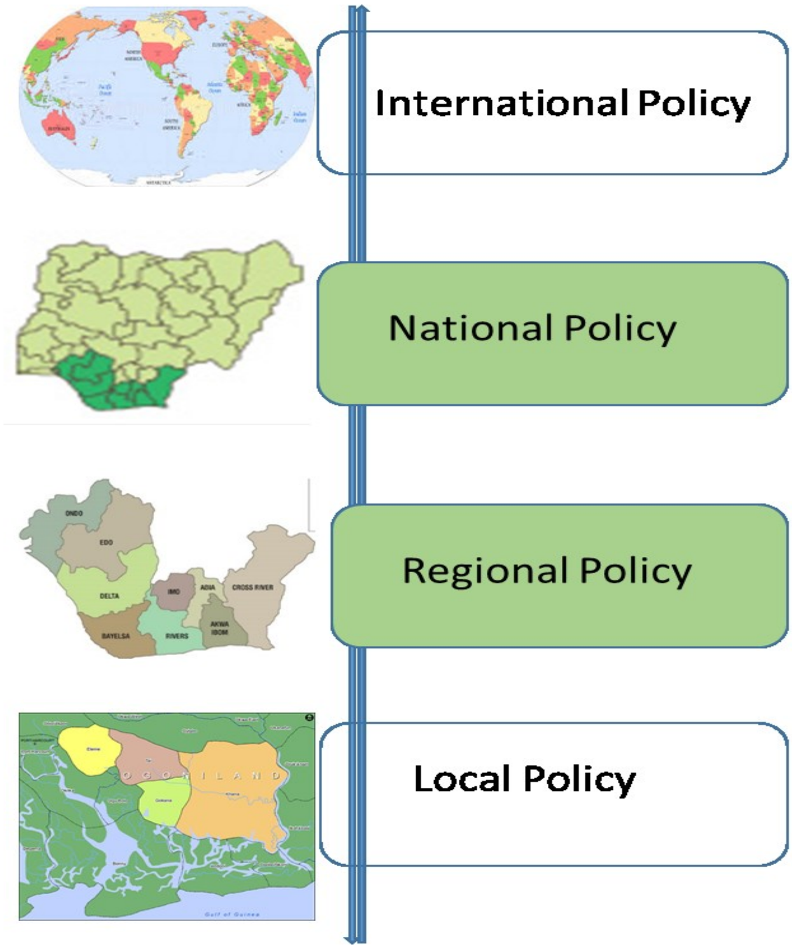
Evolution of Laws and Parliamentary Acts that has shaped extractive activities in the Niger Delta Nigeria.



Appendix 9:

Scale of policy design and interaction across four major administrative and governance domains.

The study conducted in this thesis has a regional focus, however, it has the potential of improving the national environmental policy discourse. Hence marked in green.



Appendix 10

Approval letters of stakeholder institutions that participated in the research.

(PPAR)
14 – 09 – 2016

Office of ...
RECEIVED
09 SEP 2016
Sign ...
NATIONAL OIL SPILL DETECTION & RESPONSE AGENCY (N.O.S.D.R.A.)
ABUJA

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.

The Director General,
National Oil Spill Detection and Response Agency (NOSDRA),
NAIC House 5th Floor Plot 590 Zone AO Central Business District,
Garki, FCT,
Abuja.

Dear Sir,

REQUEST FOR RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Director General.

Sir, a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am particularly keen about environmental issues in Nigeria with emphasis in the Niger Delta Region of Nigeria. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework that would ensure sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability, ensure resilience and sustainability. I have the encouragement of my department in Imperial College to engage with industries and or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into institutions in order to bridge the industry-academia divide. Research is evolving from reductionist to transdisciplinary approaches embracing academic and field experience to achieve high impact results. Moreover, my research case study is the Niger Delta and this would be a perfect opportunity to explore profoundly my research propositions in order to have appropriate systems understanding of the ecological character of the region, adaptation pathways, socio-economic implications and potential mechanisms that would mitigate vulnerability and ensure sustainable natural resources extraction and ecosystem services derived from the region. I am prepared to incorporate research experience into any project (field or desk project) and looking forward to meeting the DG or relevant personnel for further discussions. I would be grateful if you would kindly consider my request.

I wait in anticipation for your prompt and affirmative reply.

Yours sincerely,

Alozie Alaoma

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.

The Honourable Minister of Environment,
Federal Ministry of Environment Headquarter,
Block C Mabuchi,
Abuja.

OFFICE OF THE HON. MINISTER
08 SEP 2016
Sign...
FED. MIN. OF ENVIRONMENT ABUJA

Dear Madam,

REQUEST FOR RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Honourable Minister of Environment.

May I let you know that a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am particularly keen about environmental issues in Nigeria with emphasis in the Niger Delta Region of Nigeria. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework that would ensure sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability, ensure resilience and sustainability. I have the encouragement of my department in Imperial College to engage with industries and or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into institutions in order to bridge the industry-academia divide. Research is evolving from reductionist to transdisciplinary approaches embracing academic and field experience to achieve high impact results. Moreover, my research case study is the Niger Delta and this would be a perfect opportunity to explore profoundly my research propositions in order to have appropriate systems understanding of the ecological character of the region, adaptation pathways, socio-economic implications and potential mechanisms that would mitigate vulnerability and ensure sustainable natural resources extraction and ecosystem services derived from the region. I am prepared to incorporate research experience into any project (field or desk project) and looking forward to meeting the honorable Minister or relevant personnel for further discussions. I would be grateful if you would kindly consider my request.

I wait in anticipation for your prompt and affirmative reply.

Yours sincerely,

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.

The Honourable Minister of Petroleum Resources,
Federal Ministry of Petroleum Resources,
Block D, NNPC Towers,
Herbert Macaulay way,
CDB, Abuja.

Office of the Hon. Minister of State
Ministry of Petroleum Resources
Abuja
09 SEP 2016
RECEIVED
Sign.......

Thro:
The Director Planning, Research & Statistics Department,
Federal Ministry of Petroleum Resources
Block D, NNPC Towers,
Herbert Macaulay way,
CDB, Abuja.

Dear Sir,

REQUEST FOR RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Honourable minister of Environment through the Director Planning, Research & Statistics Department.

Sir, a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am particularly keen about environmental issues in Nigeria with emphasis in the Niger Delta Region of Nigeria. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework that would ensure sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability and ensure a sustainable mineral active region. I have the encouragement of my department in Imperial College to engage with industries and or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into institutions in order to bridge the industry-academia divide. Research is evolving from reductionist to transdisciplinary approaches embracing academic and field experience to achieve high impact results. Moreover, my research case study is the Niger Delta and this would

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.
22nd September, 2016.

The executive secretary NEITI,
NEITI, 4th Floor, Murjanatu House,
1 Zambezi Crescent,
off Aguiyi Ironsi Street,
Maitama, Abuja.

Dear Sir,

REQUEST FOR INTERVIEW AND RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Executive Secretary.

Sir, a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework for sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability, ensure resilience and sustainability. I have the encouragement of my department in Imperial College to engage with industries and/or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into institutions in order to bridge the industry-academia divide. Research is evolving from reductionist to transdisciplinary approaches embracing academic and field experience to achieve high impact results. My research case study is the Niger Delta Nigeria and this fieldwork is an opportunity to secure data and explore my research assumptions in order to have appropriate systems understanding of the ecological character of the region, adaptation pathways, socio-economic issues and potential mechanisms to mitigate vulnerability and ensure the sustainability of the Niger Delta Mineral Active Region. Being an institution that oversees extractive industries, I am of the understanding that you will be able to afford me data/information on environmental and socio-economic indices in the region as this would inform my research. I am keen to explore such data/information and any other valuable information the institution will provide to help

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.

The Group Managing Director,
Nigerian National Petroleum Corporation (NNPC),
NNPC Towers, Central Business District,
Herbert Macaulay Way,
P.M.B. 190, Garki,
Abuja.

9/9/16
09-46081742

Thro:
The Director Health, Safety and Environment,
Nigerian National Petroleum Corporation (NNPC),
NNPC Towers, Central Business District,
Herbert Macaulay Way,
P.M.B. 190, Garki,
Abuja.

Dear Sir,

REQUEST FOR RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Group Managing Director though the Director Health, Safety and Environment.

Sir, a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am particularly keen about environmental issues in Nigeria with emphasis in the Niger Delta Region of Nigeria. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework that would ensure sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability, ensure resilience and sustainability. I have the encouragement of my department in Imperial College to engage with industries and or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into

NIGERIAN NATIONAL PETROLEUM CORPORATION
CENTRAL BUSINESS DISTRICT, HERBERT MACAULAY WAY, P.M.B 190, GARKI, ABUJA.

www.nnpcgroup.com

Telephone: 09 - 46081000

GLD/LDL/012
September 27, 2015

Centre for environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA

Dear Sir/Ma,

RE: REQUEST FOR RESEACH OPPORTUNITY

Your letter with the above heading refers.

The management of NNPC will be obliged to assist your Ph.D. student, Mr. Alozie Alaoma on his research work. He is to report to the General Manager, Health, Safety & Environment (Shehu Ahmed Rufai), who will assist him in obtaining the necessary data required to carry out the research successfully.

Yours faithfully,
For: **Nigerian National Petroleum Corporation**

Alphonsus Ekpenyong
for: Group General Manager, Human Resources Division

cc: GM, HSE

Department of Petroleum Resources
RECEIVED
26 OCT 2016
Sign..............
Abuja

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.
26th October, 2016.

The Director,
Department of Petroleum Resources,
7, Kofo-Abayomi street,
Victoria Island,
Lagos.

Dear Sir,

REQUEST FOR INTERVIEW AND RESEARCH OPPORTUNITY

I am student of Imperial College London at the Center for Environmental Policy studying towards a doctorate in Environment and Resource Policy. My research applies Systems Thinking in the management of a Mineral Active Region and ambitions for a framework to ensure sustainable mineral and environmental regime. I have the encouragement of my department in Imperial College to engage with stakeholders; that is industries and institutions within the energy and environment that not only share research interest, but also are willing to add value to my research. My research case study is the Niger Delta and this fieldwork is an opportunity to explore my research propositions in order to have appropriate Systems understanding of the ecological character of the region, adaptation pathways, socio-economic implications. I kindly request for an interview session from key personnel in the Environment department/section of your establishment. This is to elicit views regarding environmental problems occasioned by oil and gas extraction, associated consequences and policy responses in the Niger Delta. I would also like to have a syndicate session with management to facilitate a Group Model Building Process. I am hopeful this research, process and outcome will provide useful information in policy formulation. I would be grateful if you would kindly consider my request.

I wait in anticipation for your prompt and affirmative reply.

Yours sincerely,

Alozie Alaoma
E-mail: a.alozie14@imperial.ac.uk; aloziealaoma@yahoo.com
Mobile: 07035331030 (Nigeria)
07736778444 (UK)

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.

The Honourable Minister of Niger Delta Affairs,
Federal Ministry of Ministry of Niger Delta Affairs,
10th Floor, Phase 1 Fed. Secretariat Complex,
Shehu Shagari Way,
Central Business District,
Abuja.

Office of the Hon. Minister
16 SEP 2016
Abuja
Min. of Niger Delta Affairs

Dear Sir,

REQUEST FOR RESEARCH OPPORTUNITY

I write to express my interest as aforementioned in the title of this letter addressed to the office of the Honourable Minister.

Sir, a great part of my academic journey has been spent studying and conducting research on the environment of which am enthused about. I am particularly keen about environmental issues in Nigeria with emphasis in the Niger Delta Region of Nigeria. I am a doctoral student of Imperial College London at the Center for Environmental Policy. My research applies Systems Approach in management of a Mineral Active Region to ensure sustainable mineral and environmental regime. My research ambitions for a framework that would ensure sustainable mineral and energy resource extraction while downscaling anthropogenic impacts in regions of resource deposit by understanding the complex and multiple interacting pressures on the environment to reduce vulnerability, ensure resilience and sustainability. I have the encouragement of my department in Imperial College to engage with industries and or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research by bringing research experience into institutions in order to bridge the industry-academia divide. Research is evolving from reductionist to transdisciplinary approaches embracing academic and field experience to achieve high impact results. Moreover, my research case study is the Niger Delta and this would be a perfect opportunity to explore profoundly my research propositions in order to have appropriate systems understanding of the ecological character of the region, adaptation pathways, socio-economic implications and potential mechanisms that would mitigate vulnerability and ensure sustainable natural resources extraction and ecosystem services derived from the region. I am prepared to incorporate research experience into any project (field or desk project) and looking forward to meeting the honorable Minister or relevant personnel for further discussions. I would be grateful if you would kindly consider my request.

I wait in anticipation for your prompt and affirmative reply.

Imperial College London

Centre for Environmental Policy
Imperial College London

15 Princes Gardens
Imperial College London
London, SW7 1NA
Tel: +44 (0)20 7594 7459

n.voulvoulis@imperial.ac.uk
http://www3.imperial.ac.uk/people/n.voulvoulis

Nick Voulvoulis PhD MSc DIC BSc
Reader in Environmental Technology
Director of MSc in Environmental Technology
Head of Environmental Quality Research Group

30 August 2016

Office of the Hon. Minister
09 SEP 2016
Abuja
Min. of Niger Delta Affairs

RE: Introduction letter for Mr Alozie Alaoma

Dear Sir/Madam,

I am writing to introduce Alozie Alaoma who is now completing his second year of PhD studies in the Centre for Environmental Policy, Imperial College London, in my capacity as Alozie's academic supervisor.

Alozie is studying towards a doctoral degree in Environmental Policy and his project is on the application of systems thinking to resources management, for the development of a management framework for Mineral Active Regions. He is using the Niger Delta (Nigeria) as the main area of study, and he is now in that stage of his research that needs to collect data from relevant institutions and corporations in the area, and also conduct interviews with appropriate stakeholders.

This is an important step in his PhD, as it would enable him to progress with testing important assumption behind the development of his framework with real data from his case study. Alozie has been making good progress, taking responsibility of his work and working hard to ensure that he delivers the expected outcomes. I am sure that he will deliver this task also, as he is hard working, displays initiative and can work independently. I kindly request your help to offer Alozie the assistance he requires to enable him to progress in this research.

Please do not hesitate to contact me if you need further information on this.

Yours faithfully,

Dr. Nick Voulvoulis

Centre for Environmental Policy,
Imperial College London,
15 Princes Gardens,
London, SW7 1NA.
28th October, 2016.

The Managing Director,
Total E&P Nig Ltd,
2 Memorial Close,
Central Business District,
Abuja.

Dear Sir,

REQUEST FOR INTERVIEW AND RESEARCH OPPORTUNITY

I am student of Imperial College London at the Center for Environmental Policy studying towards a doctorate in Environment and Resource Policy. My research applies Systems Approach in the management of a Mineral Active Region and ambitions for a framework to ensure sustainable mineral and environmental regime. I have the encouragement of my department in Imperial College to engage with industries and/or institutions within the energy/mining and environment that not only share research interest, but also are willing to add value to my research. My research case study is the Niger Delta and this fieldwork is an opportunity to explore my research propositions in order to have appropriate Systems understanding of the ecological character of the region, adaptation pathways and socio-economic implications. I kindly request for an interview session from key personnel in the Environment and Society department/section of your establishment. This is to elicit stakeholder's views regarding environmental problems occasioned by oil and gas extraction, associated consequences and possible policy responses in the Niger Delta. I would also appreciate a syndicate session with the management to facilitate a Group Model Building Process. I am hopeful this research, process and outcome will provide useful information in policy formulation. I would be grateful if you would kindly consider my request.
I wait in anticipation for your prompt and affirmative reply.

Yours sincerely,

TOTAL E&P NIGERIA LIMITED
RECEIVED
Date 28/10/16

Alozie Alaoma
E-mail: a.alozie14@imperial.ac.uk; aloziealaoma@yahoo.com
Mobile: 07035331030 (Nigeria)
07736778444 (UK)