

Analysis of oil spill impacts along pipelines and the fate of sensitive environments in Nigeria

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This study shows how mapping post-oil spill incidents can provide insights into the fate of sensitive ecosystems and serve as a decision-support tool for reducing the negative socio-environmental impacts of oil spills. The incidence of oil spills along pipelines have expanded in extent into habitats of sensitive natural ecosystems and threatens biodiversity conservation in Nigeria. These oil spills, directly and indirectly, influence critical ecosystems functioning such as protected areas, wildlife, wetlands, waterbodies, marine animals and plants, natural vegetation types and arable lands for food production. The geo-visualised oil spill records overlaid on GoogleEarth images provided geo-locational insights and intelligence that aid inferences on the impacts of oil spill incidents using geospatial mapping tools and web-service to support decision-making purposes in the oil spill management cycle. Furthermore, geospatial analysis of oil spills data from 2006 to 2019 along the ~5000 km of pipelines with the 2017 World Database of Protected Areas revealed numerous perils oil spills pose to the proper functioning and sustainability of terrestrial and marine ecosystems. Results showed that ~630 verified oil spills occurred in the forest reserves along the pipelines. Approximately 120 verified oil spills were recorded in game reserves and ~210 verified oil spills occurred in Ramsar site-wetlands of international importance. The oil spills that occurred along these pipelines are threats to the existence of intact tropical rain forests, savannah forests and protected areas since they intersect critical ecosystems. Numerous terrestrial and marine inhabitant were affected by oil spill events including land and underground water pollution, loss of human livelihood, heavy metal pollution, loss of farmland and damage of animal habitat. This assessment showed that the fusion of relevant environmental dataset is crucial in evaluating the fate, sensitivity and vulnerability of landscapes to oil spills using geo-mapping and geo-visualization concepts. In the context of achieving environmental sustainability and smart oil pipeline provisioning in line with the global Sustainable Development Goals (SDGs), it is essential to use Geo-information tools such as integrated spatial planning and land-use concepts to evaluate potential perils linked to oil infrastructure development. Outcomes from impact assessment research of this kind should be incorporated as strategic tools for developing informed conservation economy policies, industry practices and good environmental governance mechanism for robust decision-making in the oil and gas sector of Nigeria towards attaining local-scale SDGs.

Keywords: Biodiversity loss, Conservation, Geoinformation, Geo-visualization, Nigeria, oil spill, pipeline.

Introduction

Petroleum products derived from oil and gas activities are a major contributor to terrestrial and marine economy in Nigeria. They are one of the highly demanded and priced commodities in the extractive industry. Unfortunately, the processes involved in exploration, extraction and transportation of oil and gas petroleum products mostly impede on the environment with long-term impacts and cascading effects (Kingston, 2002). Consequently, oil and gas activities remain one of the human actions that exert numerous direct and indirect impacts on sensitive and important ecological landscapes in Nigeria.

Extant literature show that environmental pollution emanating from oil and gas activities results in serious ecological damages causing marine organisms to die or flee (Lee, 2011; Lindstedt-Siva, 1980; Moore, 2006). This result in environmental and socio-economic costs, which is a major concern to environmental scientists and managers. For example, oil spillages occur in Nigeria through oil pipelines that is one of the means of conveying refined petroleum products or crude oil from sources such as oil wells to destination mainly refinery. Oil spill incidents considered to be damaging to sensitive and vulnerable environment have occurred in oil producing regions of Nigeria. The alarming and persistent occurrence of oil spills with negative impacts causes pockets environmental devastation such as contamination of soil, land degradation, pollution of underground water, persistent vegetation cover damage, marine ecosystems and public health issues in Nigeria. This has been confirmed by the independent assessment of the Ogoniland in 2011 (UNEP, 2011).

Of particular concern is how oil spillages caused by third-party interference are occurring along oil pipelines in the Niger-Delta and is gradually spreading along oil pipelines into the hinterland of Nigeria (Figure 1). The impacts of the oil spillages on important natural habitat and how the ecological services provided by these environments are under immense attack. Here we describe an “oil spill tsunami” along petroleum products pipeline in Nigeria with focus on Nigeria’s Niger-Delta and the hinterland of Nigeria (Figure 1). Locations experiencing oil spillage in these regions have drawn intense scrutiny and concern lately. The occurrences of oil spillages contravene environmental laws in Nigeria (FGN, 2006), and does not meet international standards of environmental protection practices. Oil spillages are generally caused by third-party interference and has specifically continued because of failure to comply with the National Oil Spill Detection and Response Agency (NOSDRA) regulations derived from Act 15 establishing NOSDRA in 2006.

Across Nigeria, third-party oil spillage occurrences are expanding at an unprecedented pace and rate. These oil spillages have occurred with high density visible in the Niger-Delta as highlighted in white rectangle showing oil spill density in red circles in Figure 1. These reported

oil spill crisscross much of the Niger-Delta's fragile landscape due to the presence major oil industry operations and infrastructure since the last five decades. The tendency of oil spill is beginning to extend to the hinterland as is evident in Figure 1 (see linear pattern of red and grey circles moving northward Nigeria). The increasing pace of oil spillage in Nigeria threatens the continuity of a safe and healthy environment in Nigeria. If balanced environment is needed that does not compromise the standards of living of current and future generations, the Nigerian environment must be protected from future occurrences of oil spillages.

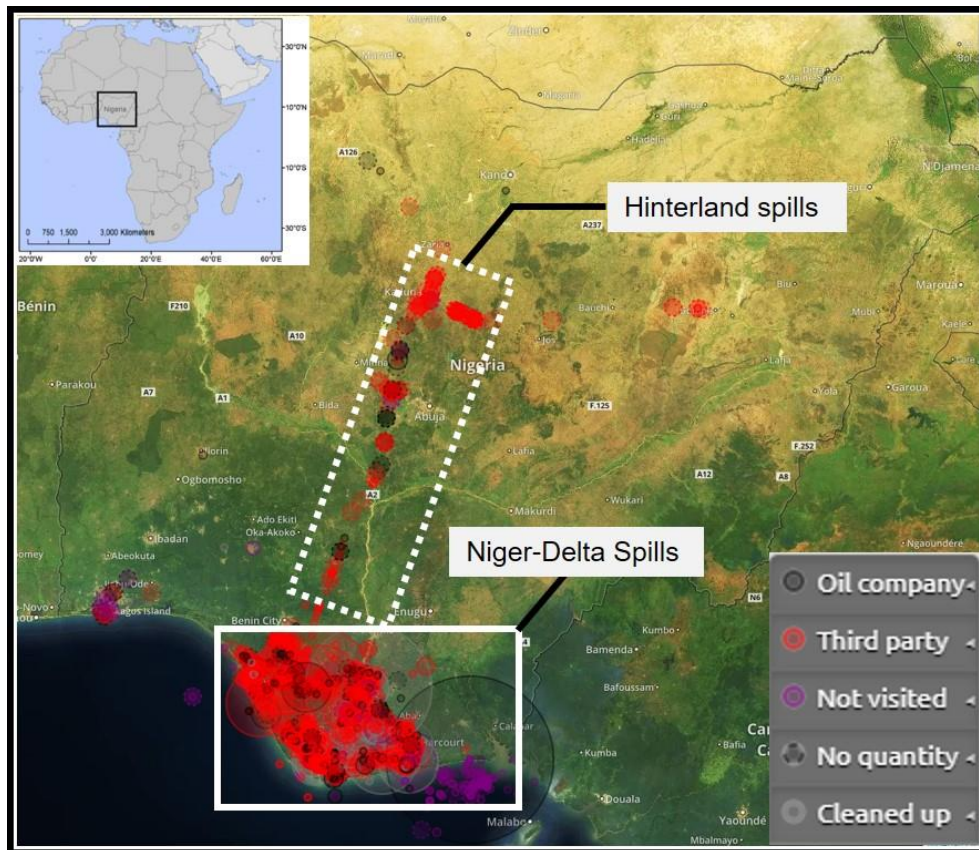


Figure 1: Geo-visualization of oil spill pattern across Nigeria in a web-GIS platform

It is essential that already impacted sites by oil spills must be well understood and managed in a spatially explicit context using an array of Geospatial Information Technologies (GIT) comprised of Global Positioning Systems (GPS), Remote Sensing (RS) and Geographic Information Systems (GIS). These tools are useful for pre and post impact analyses of oil spill to enable environmental scientists and managers provide sustainable environmental practices that support response, recovery, remediation and resilience concepts. Consequently, reducing the impacts of oil spill and land degradation, GIT support the delivery of good environmental governance frameworks that are measurable through indicators such as the global targets of the United Nations Sustainable Development Goals (SDGs).

The questions addressed in this research work are: How does the oil and gas activities threaten the well-being of Nigerian? What are the risks associated with oil and gas activities imminent to the sensitive and ecologically important landscapes in Nigeria? How can NOSDRA effectively manage oil spillages in Nigeria? With respect to policies: Are there current policies in place to help reduce environmental damage caused by oil and gas activities in Nigeria? Furthermore, this research aimed to map oil spill pattern in the Niger-Delta, along the pipeline hinterland and highlight the fate of sensitive environments in Nigeria. These questions will be addressed in the following sections. This study therefore aims to provide a comprehensive elucidation of the potentials and roles of geospatial technologies in managing oil spills especially using the publicly available archives of Landsat series, Sentinel and Google Earth platform using integrated remote sensing GIS and GPS analysis contributing to the understanding of oil spill detection and management in Nigeria.

A. Threats of oil and gas activities to the well-being of Nigeria

The enormous quantity of oil and gas deposits is seemingly the most vulnerable natural resource in Nigeria especially in the Niger-Delta (Ajibade & Awomuti, 2009). A similar situation is likely to be experienced with more recent discoveries in the hinterland. Between 2008 and 2017, over 789 billion barrels of oil were exploited from over 5000 wells (NNPC Annual Statistical Bulletin, 2017). However, the well-being of Nigeria in terms of diversified economy is threatened by the perils oil and gas activities impose on the Nigerian environment. For instance, agricultural activities including fishing is threatened in the Niger-Delta due to the occurrence of oil spill which is linked to oil and gas activities. One of the implications of oil spill to human well-being is that agriculture and food production for sustenance which is an indicator to well-being is threatened both in quality and quantity or yield. Importantly, oil spills aggravate degradation of arable land which threatens the continued sustainability of the environments used for food production and food security agenda. Overall, the well-being threats of oil spills destabilizes the socioeconomic status of oil polluted regions and consequently hinders or disenfranchises such locations from the attainments of the SDGs. Considering that oil spill is linked with oil and gas activities, it remains a major threat to Nigeria's well-being because of the country's the over reliance on revenues generated from the oil and gas industry. Yet, despite the huge income from crude oil and gas sales, this revenue has so far not helped to alleviate the large majority from chronic poverty as the most densely populated county in Africa. Unfortunately, the COVID-19 pandemic further exposed how Nigeria's well-being is threatened by the fragility of extractive commodity prices such as the drop in crude oil earnings by 90%, which affected Nigeria's 2020 budget and subsequently influenced the proposed federal government spending intents.

B. Environmental and Socio-ecological risks of oil spill in Nigeria

There are numerous socio-ecological threats prevalent and imminent to sensitive and environmentally important landscapes associated with oil and gas activities in Nigeria. The persistent oil spill incidents with hydrocarbons is one of the greatest environmental pollution threats with attendant socio-ecological risks in Nigeria. Although there are numerous causes of oil spills, here, the focus is on incidents along pipeline which impose negative impacts on land-cover such as soils, vegetation, surface water and aquifers and have damaged substantial portion of forests in the Niger-Delta (Figure 2). In truth, over 15 million barrels of oil have been spilled in the Nigerian environment since 1958 to date based on estimates of reported oil spill incidents.

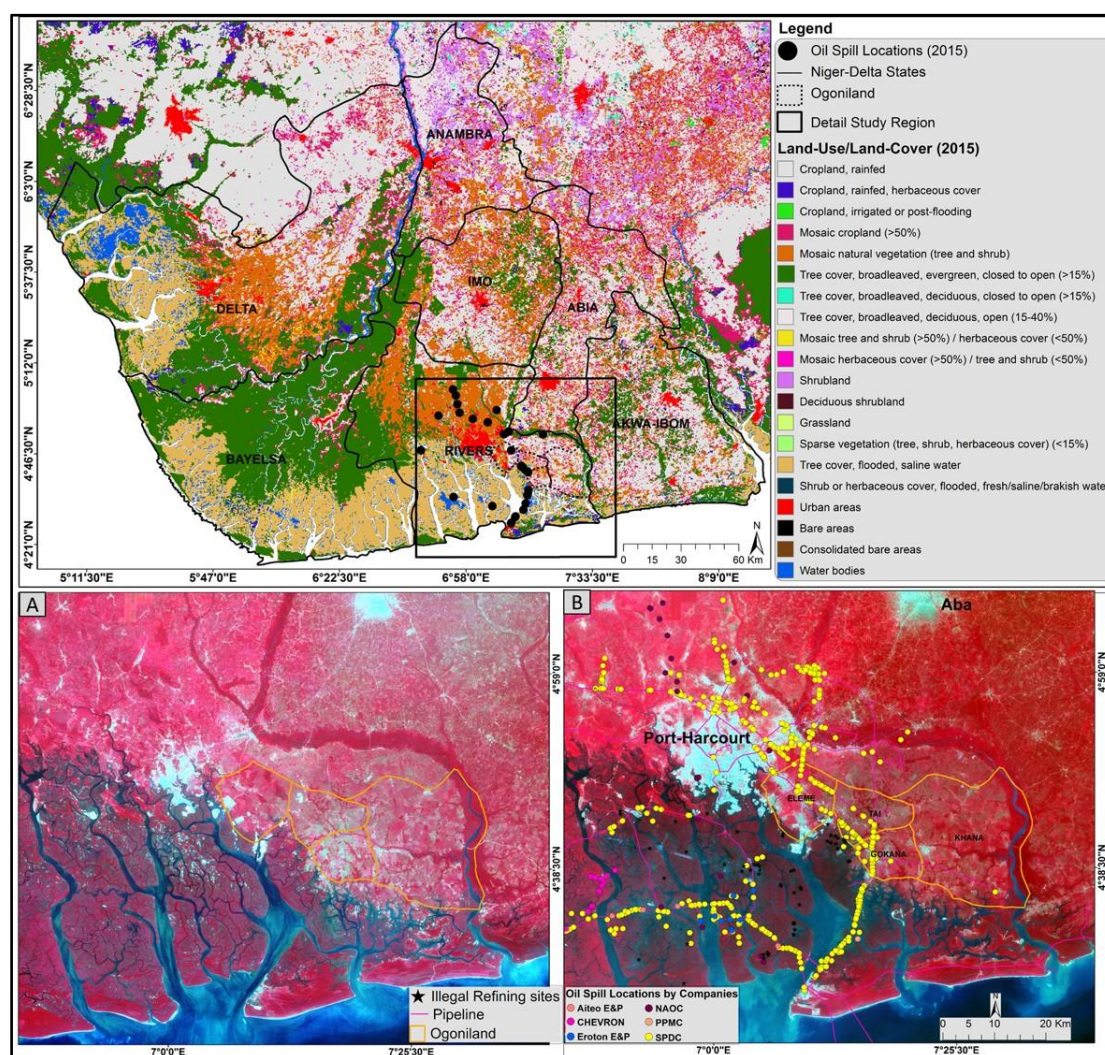


Figure 2:

Some of the long-term environmental and socio-ecological risks connected to oil spill incidents is the destruction of endangered flora and fauna, loss of biodiversity, food chain destabilization and aggravation of human health challenges (Bayode & Adewunmi, 2011; Moore, 2006). Oil spill can lead to long-term ecological impact such as biodiversity loss. For instance, the physical smothering by tar residues effectively reduces habitat diversity by binding substrata and filling of

pore spaces, which reveals the most conspicuous long-term impacts on biodiversity and productivity. Another long-term ecological risk caused by oil spill is the loss of natural forest cover and rapid change in Land-Use Land-Cover (LULC) (Figure 2). Mangroves are one of the threatened forests covers by oil spills in the Niger-Delta. The decline or extinction of this important vegetation in the Niger-Delta is strongly linked with oil spill impact (UNEP, 2011). If oil spill impacts on mangroves are not halted, the combined long-term effects will contribute some other environmental consequences such as flooding prevalent in the Niger-Delta. This further aggravate oil-exploitation related threat and by implications increases floodwater which disperses large amount of sediments into the environment as can be observed in the detail study region Figure 2.

C. Measures to effectively management of oil spillages in Nigeria

The effective management of oil spill requires compelling analysis that help to understand the current and potential effects of oil pollution on sensitive ecosystems and humans. For instance, the geospatial visualization of oil spill locations on all water bodies along pipelines in the hinterland and Niger-Delta can help identify locations of water related contamination (Figure 3). In addition, the geospatial overlay of oil spill locations on LULC can support impact assessment arguments necessary to effectively identify threatened, sensitive and vulnerable land-cover that require in-depth-case management such as remediation actions.

Despite the hard time NOSDRA is facing to proactively detect oil spills being an Agency saddled with the responsibility of implement the National Oil Spill Contingency Plan (NOSCP), the Agency has devised innovative and compelling approach to showcase and understand the potential effects oil spill can have on sensitive environments across Nigeria. Beginning from 2009, the need to mainstream Geoinformation into oil spill management in NOSDRA for Nigeria was indispensable. In 2012, there was the need to conceptualize how the collated oil spillage records can be geo-visualized for a spatial overview and further analytical capability to facilitate proactive decision-making. This focused the collaboration between NOSDRA and Stakeholder Democracy Network to develop the web-based tool now referred to as the oil spill monitor (<https://oilspillmonitor.ng/>). Considering that the Nigerian environment has a tragic record of pollution due to oil spillage, yet no systematic geospatial visualization and analysis has been available about the potential impacts of spills on sensitive ecosystems along pipelines in Nigeria. This study revealed interesting spatial pattern of oil spill especially from third-part interference across Nigeria using RS and GIS analyses (Figure 3).

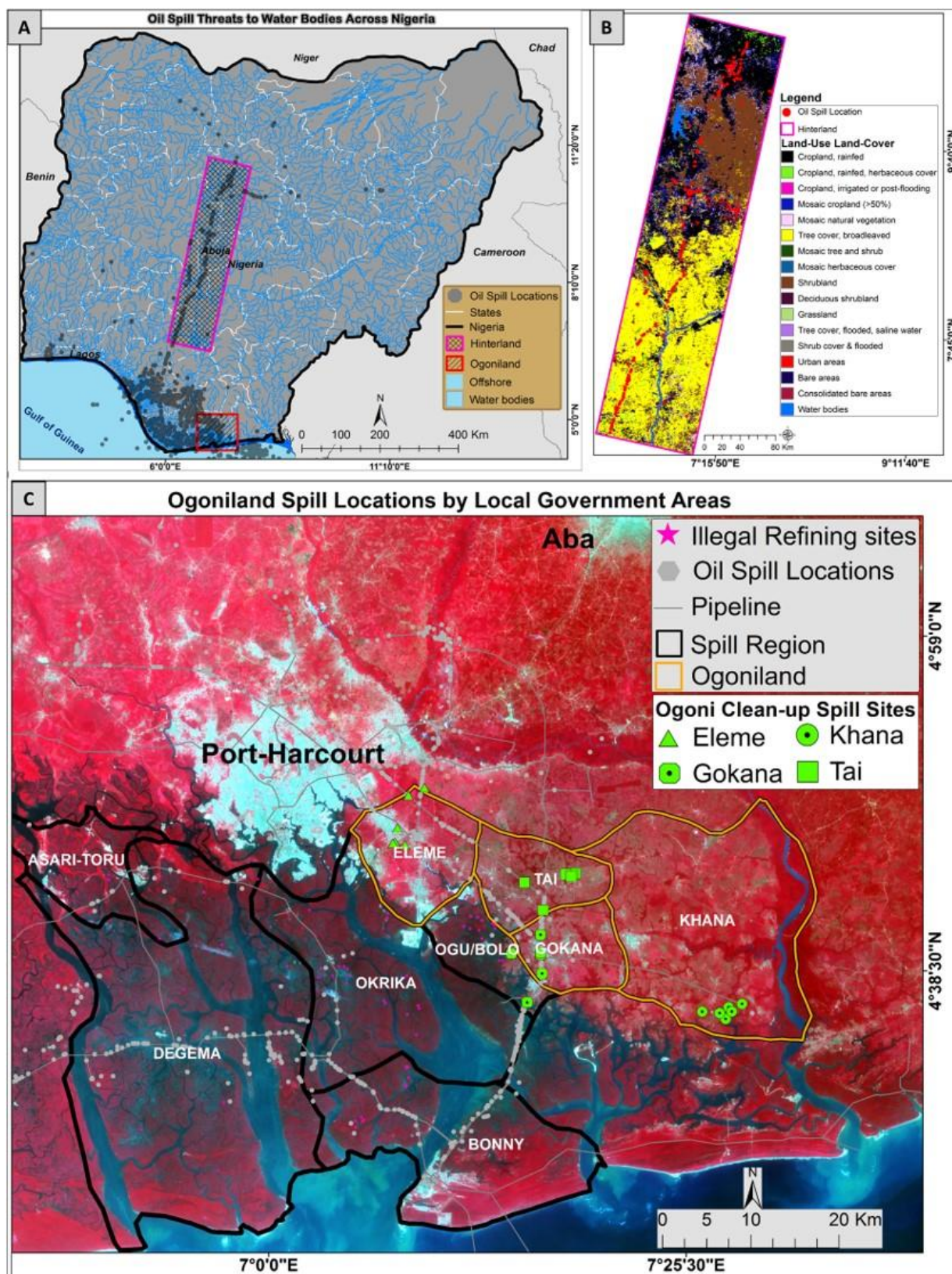


Figure 3:

D. Strategies to reduce environmental damage caused by oil and gas activities in Nigeria

The extant policies enacted to manage environmental damage caused by oil and gas activities in Nigeria may not achieve the set goal as it is. Thus, the modules of application must change.

The Nigerian Oil Spill Pattern and the Fate of Sensitive Environment

The mapping of oil spill incidents including those along pipelines is an effective effort to understand oil spill pattern, its impact on environment, prevent future oil spill incidences and strengthen oil spill response plan. Therefore, incorporating mapping in the planning and practice of oil spill response such as control, containment and clean-up becomes critical to minimize the ecological impacts of oil spills to sensitive environments in Nigeria. Clear goals of mapping as a planning and preventive measure are needed in executing oil spill response, whether at individual company level, oil clean up cooperative or state and federal government agency. In addition, the mapping of oil spill impacted sites is an effective approach to transparently carry along all group involved in oil field assessment stage to agree on actions to be achieved. This is necessary because conflicts of interest arise when transparency and traceability is lacking in site assessment and the investigation teamwork at cross purpose for different goals. For instance, responding to oil spill incidence along oil pipeline requires the stoppage of oil from source, restoration of the pipeline integrity and clean-up of the immediate environment.

A true game-changer for Nigeria nature and ecological conservation is the pattern of oil spills occurring along petroleum products pipeline across sensitive environments in Nigeria (Figure 4). If left in their entirety without clean-up and restoration, the spills would collectively have long-term ecological impacts on sensitive natural ecosystems in Nigeria.

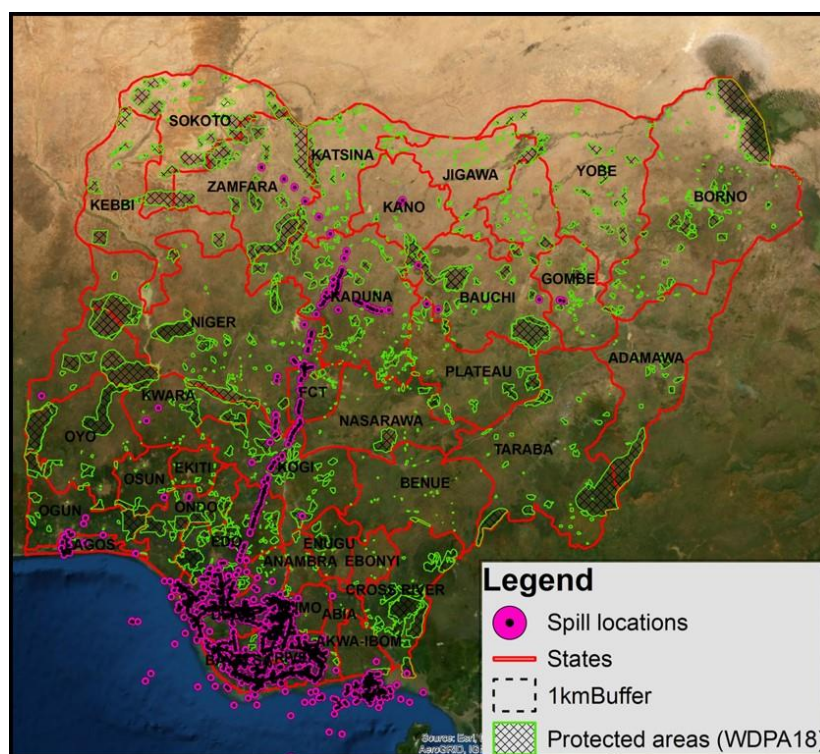


Figure 4: Overlay of oil spill pattern on protected areas layer across Nigeria

Aligning oil spill management with Sustainable Development Goals in Nigeria

To be written.

Tips of the Iceberg

The oil spill pattern along pipeline is part of an expanding network of oil spill incidents in Nigeria. In the Niger-Delta alone, oil spills occur in both terrestrial and marine environments that threatens land-use and land-cover, biodiversity, wildlife and human security. At present, oil spill in the Niger-Delta is a major cause of contaminated land, food insecurity, surface and groundwater pollution, vegetation, farming, sediment, air pollution, public health and human well-being, industry conspiracy and institutional conflicts. Unless environmental monitoring tools developed with geo-visualization and geo-analytical capabilities are developed to implement environmental safeguards are developed, the spatial impacts of oil spill will not be identified, understood and contextualised in a wider framework such the SDGs.....

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