Assessing the Impacts of Oil & Gas Transport on Nigeria's Niger-Delta Environment

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Introduction

Transportation is a crucial aspect of oil and gas development activities. Crude and refined products are normally managed using basic transport geography concepts (distance, accessibility, spatial interaction and land use) for optimum utilization by consumers all over the world. However, this, like any other anthropogenic process has significant impacts on water, land/soil and air. To exacerbate this in Nigeria's Niger Delta region, many years of social and environmental neglect by oil companies and successive governments have incited the recent trend of transport pipeline interdiction or sabotage or vandalism. Water resources (i.e. rivers) are a primary environmental receptor of oil spills from transport pipelines either caused by vandalism or rupture (e.g. corrosion). Recent findings suggests an increase in annual reported cases of vandalism and this underpins the urgent need to further complement current efforts to protect environmental resources, especially water. Though many innovative research efforts have been undertaken to address environmental degradation in the Niger Delta, these are yet to yield the desired results. The work described here departs from traditional approaches and attempts to examine current Environmental Impact Assessment (EIA) procedure in the oil and gas industry alongside a transport geography model as the potential basis to address oil and gas transport related problems in the region. The aims of this work are therefore:

i. To explore a modification of current EIA protocol to include basic geospatial approach i.e. Geographic Information Science (GIS) and Remote Sensing (RS).

ii. To analyze river flow, stage and velocity data to model oil travel pattern and minimum allowable response time to curtail spills downstream of river environment.

iii. Modify the Transport Geography Model (i.e. connectivity matrix) to reflect the reality of volatile environments like the Niger Delta, Azerbaijan, Georgia, Iraq etc. where acts of vandalism has been reported on oil/gas transport pipelines.

Brief review

Based on the 2002 International Energy Agency report, Chapman (2007) posited that the global transport impact of our dependence on fossil fuels on the environment is not limited to vehicular emissions but includes the transportation of oil itself. Oil and gas transportation has been identified as one of the key activities resulting in environmental diseconomies that affect water and air quality features in the Niger Delta (Orubu et. al. 2004). Pipelines are comparatively more economically viable in terms of accessibility to remote locations, distance coverage, speed and the efficiency with which fluids such as water, oil, gas, slurry and other liquids are transported (Lawler 1996, Fricker & Whitford 2001, Degermenci 2001, Oni 2002). Exploration and transport of oil/gas resources commenced in Nigeria's Niger Delta in 1956 with reactive rather than proactive environmental regulations in place. Non-maintenance and intentional attacks on an existing supply service system, whether considered as sabotage, vandalism or 'interdiction' (Church et al. 2004), leads not only to loss of critical infrastructure but also pollutes the environment. Transportation of oil and gas (i.e. hazardous materials, see Douligeris et. al. 1997) has potential for adverse impacts on humans and the environment, especially since oil storage facilities and major oil transport pipelines cross or are located close to rivers (Yapa & Shen 1994). This has been dealt with in a

number of environmental and transportation literature but apparently with more emphasis on land (e.g road, rail) and coastal/marine transportation (see Brekke & Solberg 2005, Orubu 2004, Twumasi & Merem 2006). On the other hand, gas flaring has been linked to air pollution problems causing the growth and flowering of some plants to be suppressed, thereby reducing agriculture and animal concentration in the Niger Delta (Orubu 2004). An efficient transport-based Gas Development Master Plan could possibly provide a solution to the long awaited Gas flare-out date while promoting environmental sustainability, industrial growth and increased revenue.

The Study Area

The Niger Delta (Fig. 1) is located in southern Nigeria and is world's third largest wetland. It is characterized by significant biological diversity and contains the bulk of Nigeria's proven oil and gas reserves. The region has about 606 oilfields with 355 situated onshore and 251 offshore (Fig. 2a). There are about 5,284 oil wells drilled and 527 flow stations for crude oil processing, with more than 7,000 km of oil and gas pipelines (Fig. 2b) traversing the entire area and seven export terminals. The land area within which the network of transport pipelines are located is estimated

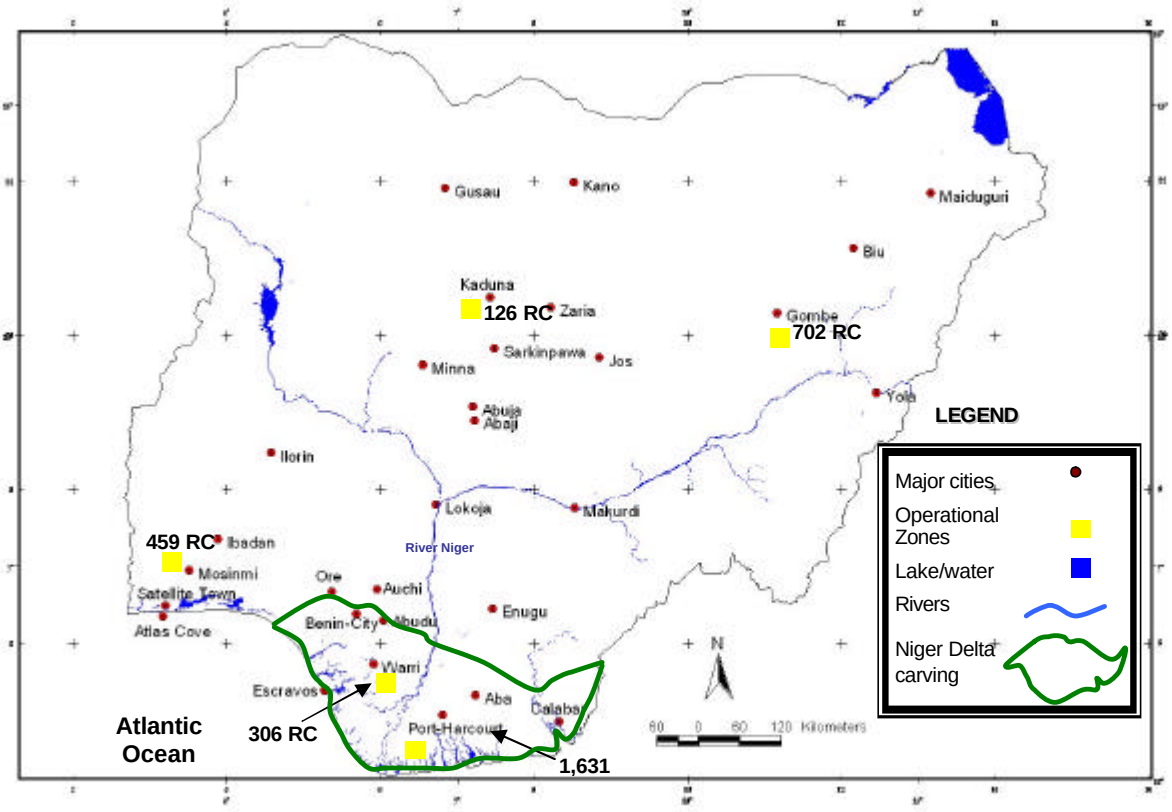

Figure 1: Nigeria showing Niger Delta, major cities & 5 Operational Zones
Source: after Anifowose (2006) NB: RC – Reported Cases of pipeline

at 31,000 km^2 (NDRDMP, 2006). There are ten gas plants and about 30 marginal oil fields farmed out, through the network of pipelines, to local companies and for export. Three of Nigeria's four refineries, Port-Harcourt I & II and Warri, are located in the region, while the fourth is located in Kaduna, northern Nigeria. A vital water resource in the region, the Niger River is third longest (i.e. approx. 4,160 km) in Africa after Nile and Congo rivers respectively.

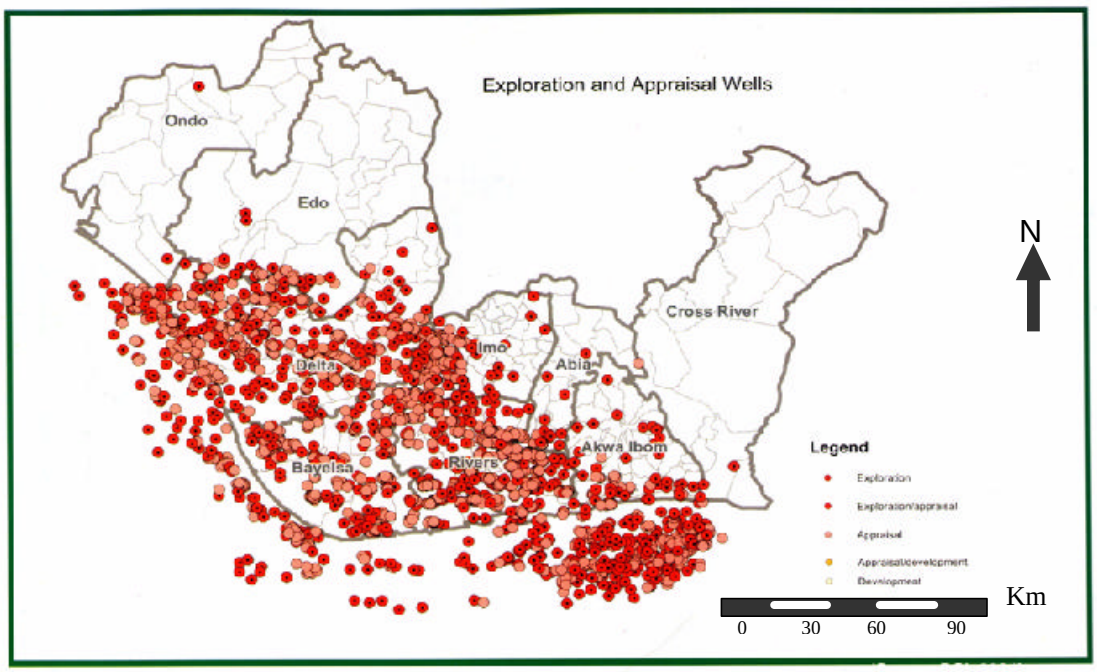

Figure 2a: Niger Delta showing the Distribution of Onshore and Offshore oilfields
Source: NDRDMP , 2006

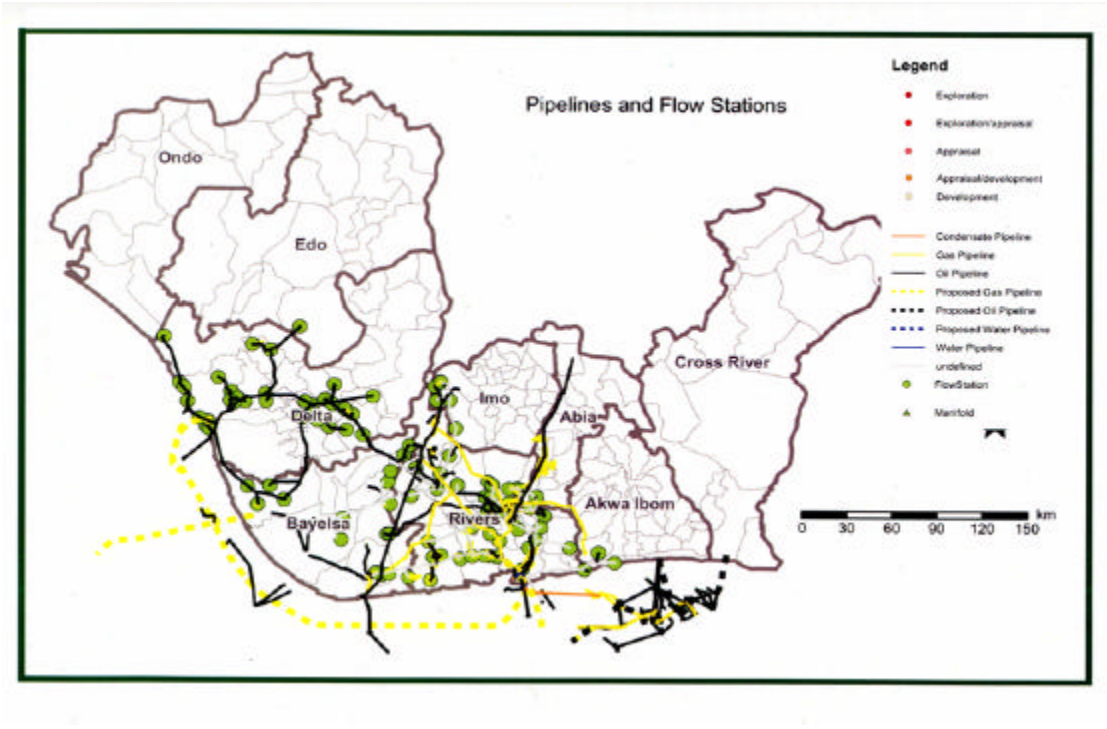

Figure 2b: Oil & Gas Pipeline Transport Network connecting other infrastructure in Niger Delta

Conceptual Framework

Environmental Impact Assessment (EIA)

EIA (Fig. 3) is an important conceptual framework within which screening, scoping of potential impacts, mitigation, alternatives, monitoring plans and other key issues that may arise from proposed project developments, policies and programmes are identified in advance. EIA for pipeline projects can be broken down into four major phases: construction, hydro-testing, operation (post-project) and decommissioning (Lawler, 2003; Lawler et al., 1996). A Water Impact Assessment (WIA) protocol for oil pipelines to better protect water resources was proposed by Lawler (2003).

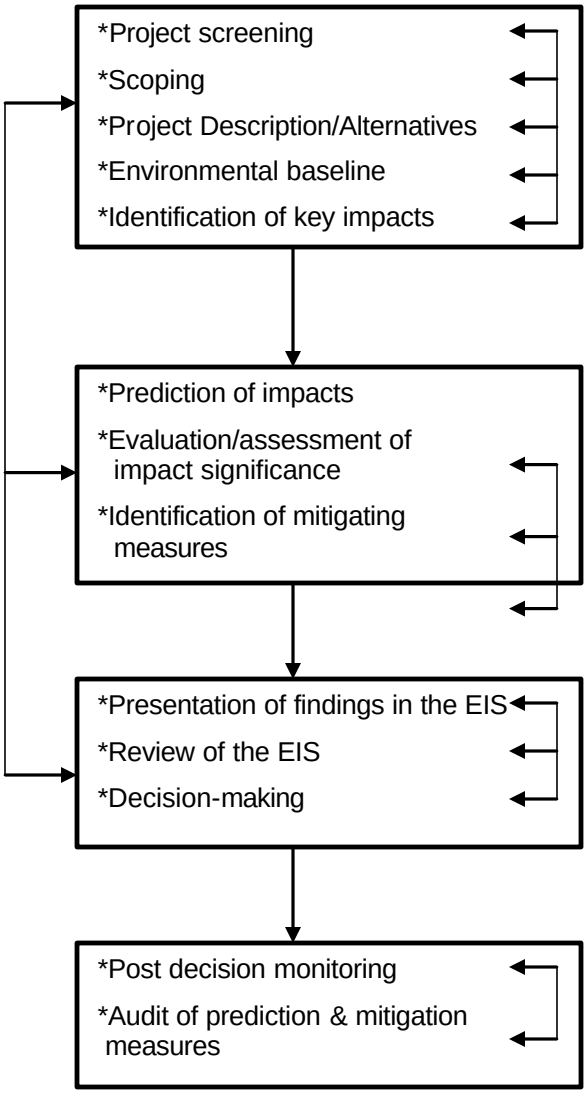

Fig. 3: Key stages of EIA procedure, after Glasson et al. 2005

Patil et al. (2002) identified two main EIA techniques: conventional and geo-spatial. The conventional EIA is where field sampling and analysis are carried out with results presented often in a cause-effect matrix pattern. Geospatial EIA techniques involve a mathematical model based on spatial data derived from satellite imagery.

Transport Geography Model

Rodrigue et al. (2006) develop a theoretical framework with which to understand the factors that could impede the free and smooth flow of people and materials in space. The combination of four common interrelated concepts forms the Transport Geography Model: namely distance, accessibility, spatial interaction and land use (Fig.4). Oil and gas resources at a particular location will remain inaccessible and of less value unless the distance (impedance) between such location and the point of consumption is bridged through transport infrastructures like pipelines, trafficable roads and tankers. This model is relevant because distance needs to be overcome for oil and gas resources to serve its purpose. Transport pipelines sabotaged or ruptured could disrupt flow and undermine the Transport Geography Model; hence the need for continuous monitoring to enhance environmental management practices such as quick response time, location identification, manpower deployment and disaster prevention.

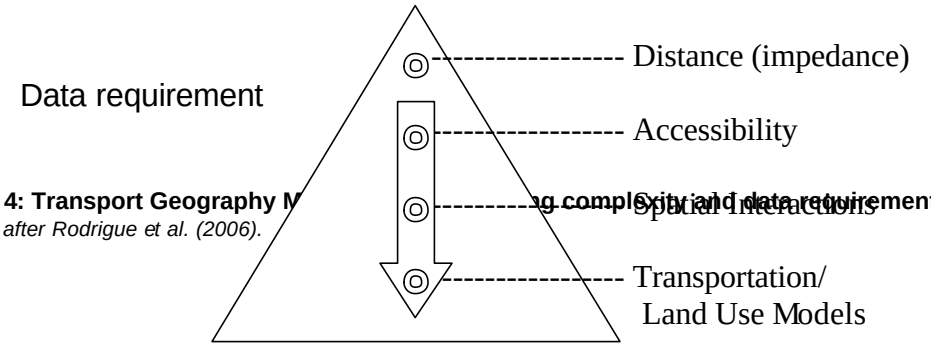

Figure 4: Transport Geography M g complexity and data requirements.
Source: after Rodrigue et al. (2006).

Data and Methodology

Periodic data on pipeline transport vandalism, product loss, water pollution and series of fire outbreaks based on five geographical locations as well as the estimated volume of lives lost will be sourced from the Nigerian National Petroleum Corporation (NNPC), Department of Petroleum Resources (DPR) and other secondary sources. Sources of data on river flow (from monitoring stations in the study area) and air quality include Environmental Agencies, Government Ministries, Oil & Gas Companies, existing EIA/ESIAs and review of journal papers. Statistical analysis such as time series plotting, correlation and regression analysis, digital image interpretation, spatial modelling and overlay analysis (GIS) are some of the key methods that would be used in data analysis while results will be presented in form of maps, charts, line graphs, scatter-plots etc. It is hoped that the integration of the Transport Geography Model into the key stages of oil transport pipeline EIAs (with geospatial capability) will allow effective monitoring, location identification and mitigation of vandalism-related pollution.

Preliminary findings

Key findings so far are:

a. Measurement at Lokoja (Fig. 1) suggests that flows are highly seasonal, with discharge peaking between September and October. Discharges vary from ~2000 m3 s-1 to almost 18,000 m3 s-1. However, flow peak magnitudes vary widely between individual years (Fig. 5). This is essential as it may be useful for predicting oil spread rate for pipeline failures (e.g. vandalism) at river crossings, and for evolving effective water resource management strategies at different periods of the year (see Lawler, 2005).

b. Underutilization of geospatial technology in EIA protocols (see Gunasekera 2004 etc.)

c. The Transport Geography Model and its connectivity matrix do not factor interdiction or vandalism into consideration (see Rodrigue et al.2006).

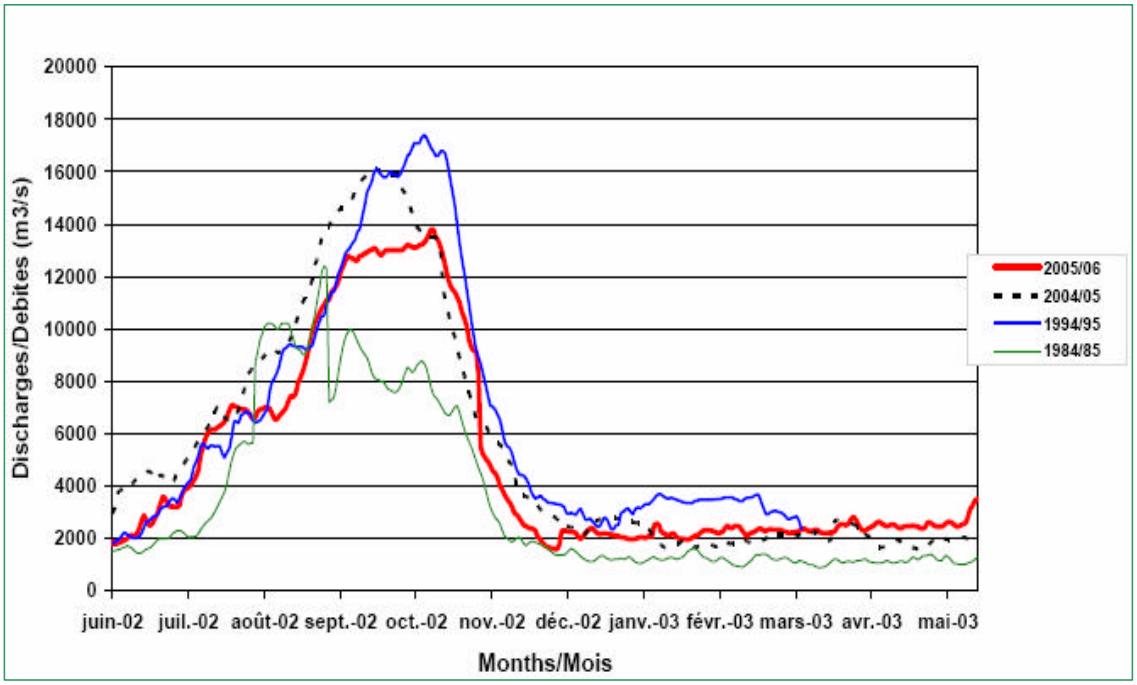

Figure. 5: Comparative Hydrograph of River Niger at Lokoja *Source: Olomoda 2006*

Future work

Identifying river flow pattern, stage and velocity in key monitoring stations especially where transport pipelines cross rivers within the Niger Delta is important. Hydrological datasets from 1914 to early 1990s will be collated from these stations to project likely oil travel pattern and the minimum allowable time for intervention before possible spread downstream of river environment. Second, collation of past oil pipeline EIAs executed within the study area to assess the level of compliance with international best practices and determine the use of geospatial tools. This will help suggest plausible modification to existing EIA protocol. Third, modification of the Transport Geography Model to reflect the reality, not only in the Niger Delta but also in other places like Azerbaijan, Russia, Georgia, Iraq etc. where similar acts of vandalism have been reported on oil and gas pipelines.

Conclusion

This paper has attempted to identify some gaps in past efforts to address environmental problems in Nigeria's oil and gas industry. It specifically stated oil and gas transport pipelines as possible source of environmental degradation due to rising rates of vandalism in the Niger Delta. However, it is worth noting that transport pipeline interdiction is a social problem and this work in no way claims to have solution for it but rather aims at an efficient EIA protocol based on geospatial technology. This hopefully will help mitigate pollution by improving environmental management response and effective monitoring of transport pipeline corridor, especially with the integration of revised Transport Geography Model. The importance of this study lies in its potential to save human lives and better protect the environment of the study area. This may be considered timely given the Government's projected increase in oil and gas production from 3m b/d to 4m b/d by 2010. On the global scale, it will evolve improved Environmental protection and sustainability and stronger EIA systems for the oil and gas industry and the world at large.

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