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A multi-perspective view of the effects of a pipeline explosion in Nigeria

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ABSTRACT

Vandalisation of petroleum pipelines is a major cause of pipeline fire disasters. However, except the number of deaths recorded, little information of the effects of such disasters on the environment is often reported in developing countries, and post-disaster remediation process is thus usually unmonitored or ineffective. This study investigated the effect of a major pipeline disaster in a rural environment in Nigeria from multi-date satellite imageries (orthophoto map, Landsat Enhanced Thematic Mapper Plus, ETM+ and IKONOS), social and ecological surveys. Results showed that some of the affected settlements were within the pipeline corridor before the disaster, and pipeline vandalisation was encouraged by one or more cases of faulty and exposed pipeline, deficient pipeline monitoring system, sabotage and readily available markets for siphoned oil. Ecological effects include loss of about 200 ha of vegetation resulting into significantly lower woody and herbaceous plant species in the affected regions than the adjacent plots. Significant proportion of the survivors also reported lower quality of groundwater (well water), air and streams, health problems (mainly abdominal pain) after they drank the well water and destruction of their crops and farmlands. The study concluded on the need for enforcement of the right-of-way laws on pipelines in Nigeria.

1. Introduction

Petroleum or crude oil is one of the most valuable natural resources in the world [35], and a major source of economic and infrastructural growth to the Middle East, Europe and the Americas [43]. On the other hand, the quest for petroleum and other natural resources has caused internal and international crises, including wars in the source communities, especially in Africa [43,46,68,80]. It has been observed that petroleum exploration and processing have caused environmental pollution, ecosystem disruption and human losses in many developing countries [10,39,80]. These problems have been aggravated by poor environmental planning, corruption and inconsistent government policies on environment [63,9].

Studies (such as [76,41]) also suggest that the priorities given to the need for urban development and financial enrichments in many countries often jeopardise environmental sustainability. For example, as explained by Pepper [60] using the Friedman's core-periphery model [28], the areas where petroleum resources are exploited (resource base) are often characterised by economic and environmental impoverishment following continuous exploitation while the development of the urban centre (which is usually a government administrative seat, e.g. [6]) is

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prioritised. Although studies (such as [73,59,21]) have shown that many of the urban centres are later engulfed in infrastructure and population problems created by the increasing number of forced migrants, the impoverished resource bases also often become homes to armed struggles, ecological degradation and poverty [65,8,20].

In Nigeria, petroleum resources have become important source of economic gains and the resource bases have expectedly come under intense focus of armed struggle and environmental pressure [53,56]. The land area of Nigeria is about 923,800 km^2, and there are about 5120 km pipelines, which are managed by the Nigerian National Petroleum Company (NNPC) through its subsidiary Products and Pipelines Marketing Company to supply their contents to facilities in different part of the country. Vandalisation of the pipelines (an illegal or unauthorised act of destroying or puncturing oil pipelines either to disrupt supply or siphon crude oil – or its refined products – in order to appropriate for personal use or for sale on the black market or any other outlet) is outlawed by the provisions of 'Production and Distribution (Anti-sabotage) Act' and the 'Criminal Justice (miscellaneous provisions) Decree of 1974' [61]. In addition, the Nigerian Oil Pipeline Act, NOPA (Chapter 338 LFN, 1990) established right-of-way (ROW) stipulated a 47.5 m buffer around the oil pipeline where human activities, including farming and building are unexpected. Studies have however shown that the measures are inadequate as pipeline vandalisation occurred, with significant consequences [1,9,26,77]. Most of these studies also suggested that the management of the pipeline is poor, and information tracking about the facilities is deficient.

While the impact of oil pipeline vandalisation on communities in Nigeria have occurred mostly in newsprints, as unpublished non-governmental sponsored reports (such as White, 2007; [1]) or laboratory models [24,38,40], specific effects of this disaster are rarely known. Except for the study by Fadeyibi et al. [26] which provided information on different degrees of burns suffered by the victims of the pipeline vandalisation related disaster in Nigeria, most other studies have been limited to the consequences of oil spillage [36,41] and fewer studies have focused on the spontaneous and more severe effects of pipeline explosion inferno on the immediate environment. Oil spillage is known to have displaced farmsteads, destroyed farmlands, ancestral homes, lives and properties, and caused ecological instability in the Niger Delta region in Nigeria [36,41].

This study investigates the effect of the December 26, 2006 pipeline explosion in a rural community (Ilado-Odo) around Lagos in Nigeria, which killed more than 250 people, the day it happened [77,1]. This pipeline explosion incidence in Ilado-Odo community is one of 14 different cases that happened in Nigeria between 1998 and 2006; the most deadly occurred in October 1998 at Jesse, Niger Delta and killed above 1200 people [26]. Pipeline explosions have also recurred in some places; it may therefore be of importance to identify some of their causes and discuss the vulnerability of potential areas. Cardona [16] defined vulnerability as the physical, economic, political or social predisposition of a community to damage in the case of a destabilising phenomenon of natural or anthropogenic origin. We think that the pipeline explosion in Nigeria is of anthropogenic origin, and we have selected the site of the most recent vulnerable community (Ilado-Odo, Lagos State) as a case study of the affected and vulnerable communities for study. While we considered that Jesse or other vulnerable sites in the Niger Delta region would have been more appropriate, the security challenge in the region, especially for people outside the region made it difficult to select Jesse for study (refer to [54] and [74] for information about the security challenges in the Niger Delta of Nigeria). We, nonetheless, know the present study area typifies the condition of pipeline explosion in most developing countries. Specific objectives are to describe the effects of the explosion on the vegetation and examine the perception of the survivors on the causes and effects of the explosion. We approached this study from the hypothesis of Smith and Loza [70] that the ability to combine data from digital and social surveys, laboratory readings, and spatial information in a geographical information system can be adequate for effective environmental management. This study therefore focuses on the effect of disaster from pipeline explosion in Nigeria, requiring a future post-disaster recovering monitoring, which can be adopted or improved upon for any disaster in other locations.

1.1. Study area

Ilado-Odo is a rural community in Amuwo-Odofin Local Government Area (LGA) of Lagos State, Nigeria, and it is located within 6° 24′N 3° 20′E; 6° 26′ N 3° 22.5′E. Ilado-Odo community comprises four clans; 'Idimangoro', 'Sanke', 'Okun Glass' and 'Inuegbe', all of which are only accessible from the urban areas by means of water transport, including speed boats and canoes. The landuse before the pipeline explosion (in 2005) as shown in the Landsat ETM+ imagery shows that about 7.8% of the land cover was forest (a mix of mangrove or swamp and rainforest, Iloeje [37]), 39% was built-up, 25% was farmland, 17 and 10.6% were occupied by oil pipelines and roads while 10.6% was water body.

2. Materials and methods

Three approaches were considered for this study. First, spatial (geographical) information analysis was undertaken to evaluate the vulnerability of the affected settlements and access the effect. Using this approach, a multi-datasets including orthophoto map, Landsat Enhanced Thematic Mapper Plus, ETM+ (2005) and IKONOS (2007) imageries of the study area were used. Landsat ETM+ is one of the recent Landsat series launched to with unique tool to measure and monitor tropical forests at a high spatial and spectral resolution. It contains six spectral bands with a spatial resolution of 30×30 m^2, one panchromatic band (15×15 m^2), and one thermal band (60×60 m^2) [27]. IKONOS satellite, which was launched in 1999 by Space Imaging (SI), is considered suitable for ecological assessment [45].

Subsequent analysis include gathering ground-truth information, image processing and image classification as described by Gers and Schmidt [31]. A handheld Global positioning system (GPS) (Magellan model; accuracy level is ± 10 m) was used to identify the coordinate of obvious (well dispersed) benchmarks as training samples for