

**STRATEGIC USE OF GIS IN CONTROLLING PIPELINE VANDALISM OF
OIL AND GAS INDUSTRY IN NIGERIA**

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DEDICATION

To my late Father, Mother and beloved Wife

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ABSTRACT

Nigeria is among the top ten nations of the world that is endowed and blessed with oil and gas. However, the oil and gas industry has contributed a lot in generating revenue to the country but unfortunately that has not impacted much to the social and structural developments of the people in Nigeria. Level of poverty increased which led to high rates of crime and criminal behaviors like petroleum pipeline vandalism that is common in the oil communities in delta state of Nigeria. This type of crime is mostly committed by the jobless youth who are looking for alternative means to success. The aim of this study is to investigate the potential use of GIS as a strategic tool for oil and gas industry for controlling pipeline vandalization in the oil communities of Jesse, Ekakpamre, and Oviri in delta state of Nigeria with objectives set to support the aim of study. GIS techniques were used and its abilities were demonstrated in controlling petroleum pipeline vandalism using ArcGIS 10.2 software. The analysis used includes hotspot analysis, kernel density analysis and proximity analysis, and hyper link to show the photographs of the vandalism incidents. In addition, pattern of vandalism incidents in the form of pie and bar charts. The results of this study proven that GIS can be used as a strategic tool for oil and gas industry as well as it can be a useful tool for decision makers to plan, control and monitor the pipeline vandalism in Nigeria.

ABSTRAK

Nigeria merupakan antara sepuluh negara tertinggi di dunia yang dikurniakan dan diberkati dengan minyak dan gas. Walau bagaimanapun, industri minyak dan gas telah banyak menyumbang dalam menjana pendapatan untuk negara tetapi malangnya ianya tidak memberi kesan kepada perkembangan sosial dan struktur penduduk di Nigeria. Tahap kemiskinan yang meningkat telah membawa kepada kadar jenayah yang tinggi dan tingkah-laku jenayah seperti vandalisma terhadap paip petroleum dan gas dalam masyarakat minyak di Negeri delta, Nigeria. Jenayah jenis ini kebanyakannya dilakukan oleh golongan belia yang menganggur yang mencari cara-cara alternatif untuk memenuhi inspirasi dan cita-cita mereka. Kajian ini bertujuan untuk menyiasat potensi penggunaan GIS sebagai alat strategik untuk industri minyak dan gas bagi mengawal vandilisma paip petroleum dan gas dalam komuniti minyak di Jesse, Ekakpamre dan Oviri dalam negeri delta, Nigeria dengan objektif-objektif yang ditetapkan untuk menyokong tujuan kajian. Teknik GIS telah digunakan dan kemampuannya telah ditunjukkan dalam mengawal vandalisma paip petroleum menggunakan perisian ArcGIS 10.2. Analisis GIS yang digunakan termasuklah analisis hotspot, analisis ketumpatan Kernel proximiti dan Hiperlink untuk menunjukkan gambar-gambar kejadian vandalisma. Selain itu, pola kejadian vandalisma dalam bentuk carta pai dan carta bar. Keputusan kajian ini membuktikan bahawa GIS boleh digunakan sebagai alat strategik untuk industri minyak dan gas serta ia boleh menjadi alat yang berguna untuk pembuat keputusan untuk merancang, mengawal dan memantau vandalisma paip petroleum dan gas di Nigeria.

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LIST OF ACRONYMS

AM/FM	Automated Mapping / Facilities Management
BC	Before Christ
CAD	Computer-Aided Design
CNDOD	Coalition of Niger Delta Organizations in Diaspora
DPR	Department of Petroleum Resources
FBI	Federal Bureau of Investigation
GIS	Geographical Information System
GMT	Greenwich Mean Time
GPS	Global Positioning System
G&G	Geophysical and Geological Data
IMS	Infrastructure Management Systems
INS	Inertial Navigation Systems
MC	Multinational Companies
MNOCS	Multinational Oil Companies
NAOC	Nigerian Agip Oil Company
NDDC	Niger Delta Development Commission
NDVF	Niger Delta Volunteer Force
NNPC	Nigerian National Petroleum Cooperation
OPEC	Organization of Petroleum Exporting Countries
ROW	Right of Way
SDSS	Spatial Decision Support Systems
SPDC	Shell Petroleum Development Company
USA	United States of America
USEPA	United States Environmental Protection Agency

WCPD

Wealth Creation Preservation and Dona

CHAPTER 1

INTRODUCTION

1.1 Introduction

The oil and gas industry is an extremely important segment of the world economy. This industry is a major source of income for many countries of the World such as Saudi Arabia, Russia, China, Iraq Kuwait, Nigeria etc. The oil and gas industry is rapidly growing due to horizontal drilling and high volume hydraulic fracturing. This development has provided fresh jobs and economic stimulus (Witter *et al.*, 2014). However, the safety of oil and gas infrastructure from vandalization events is critical to quality, healthy and safe environment. The persistent growth in population and the associated urban explosion, most of the petroleum pipelines carrying products are presently passing through city centers.

The petroleum pipeline right of ways in Nigeria refers to the 50m distance beginning from the middle of the pipelines within which other land uses are not allowable (Brume, 2007). Petroleum pipeline network presently measures over 7,000km in Nigeria (Agbazie, 2004). The pipelines cover vast tracts of land throughout the country, changing the original ecosystem and the environmental biodiversity of the locations through which they pass (Nnah and Owei, 2005).

In Nigeria over the past decades, the pipelines with their associated rights of way have suffered sequences of acts of vandalism, to the level that the Nigerian Government have think of the possibility of burying the pipelines 12m beneath the surface of the earth, where they will be no or less vulnerable (Chika-Amanze and Edomaruse, 2007). This decision, nevertheless is unsustainably expensive, and would also aid only as a provisional measure because it is not a permanent solution for the vandalism cases (Unite, 2011).

How to solve this problem? Probably there are many ways or alternatives available. Yet present technology probably GIS is the best solution as GIS is a computer system comprises of hardware and software, designed to permit users to obtain, process, analyze and retrieve large volume of referenced data and related attribute data collected from several sources (Rahman and Rahman, 2010). However, GIS can be used as a strategic tool for control and proper management of such problems.

1.2 Problem Identification

The measure of petroleum pipelines in Nigeria is about 7,000km in length (Agbazie, 2004; Nigerian National Petroleum Cooperation, 2002). The right of way (ROW) is 50m in terms of their width (Brume, 2007). The petroleum pipelines and their associated ROW are spread across the length and breadth of Nigeria. The pipelines network cuts across all the six politically zones of the nation, starting from the south in coastal mangrove forest region, through middle belt in Guinea savannah region, and to the northern region of Sahara (Nnah and Owei, 2005).

In some of the locations affected by the pipelines, the initial ecosystem of the ROW has already been permanently altered, creating varieties of socioeconomic and environmental dilemmas. These problems have triggered conflicts which led to

vandalization of the pipelines which has resulted to a number of undesirable consequences in Nigeria. So far, the technique used to solve or control this problem is either conventional, mapping only, or GIS but still insufficient and not effective.

It is therefore necessary to develop a strategy for controlling the activities of vandals and vandalization, the complexity of this task requires mapping and analyses of the vandalism in the study area. The use of GIS as a strategic tool to tackle this problem is offered in this study. Based on the above problem, the main research question to be answered by this study is how can GIS be used as a strategic tool for controlling pipeline vandalism in oil and gas industry?

1.3 Aim and Objectives

The main question to be answered by this study is transformed into the aim. Therefore, the aim of this study is to investigate the potential use of GIS as a strategic tool for oil and gas industry for controlling pipeline vandalism.

The following objectives are set to support the aim of the study:

1. To conduct a comprehensive review of the oil and gas activities and pipeline vandalism events in Nigeria.
2. To analyses the pipeline vandalism events in some part of Delta State of Nigeria.
3. To evaluate the use of GIS as a decision tool for managing pipeline vandalism in oil and gas industry.

1.4 Specific Research Questions

The objectives will be supported by the following specific questions:

1. What are the key activities in oil and gas industries?
2. What is the trend of vandalism in Nigerian oil and gas industry?
3. Where do most vandalism activities occur in Nigeria?
4. What is the typical usage of GIS in controlling Petroleum pipeline vandalism in oil and gas industry?
5. How will GIS help in controlling vandalism in oil and gas industry?

1.5 Scope of the Study

The scope of the study is limited to Jesse, Ekakpamre, and Oviru Court oil communities of Delta State part of Niger Delta in South south region of Nigeria as a case study. Figure1.1 shows the study area.

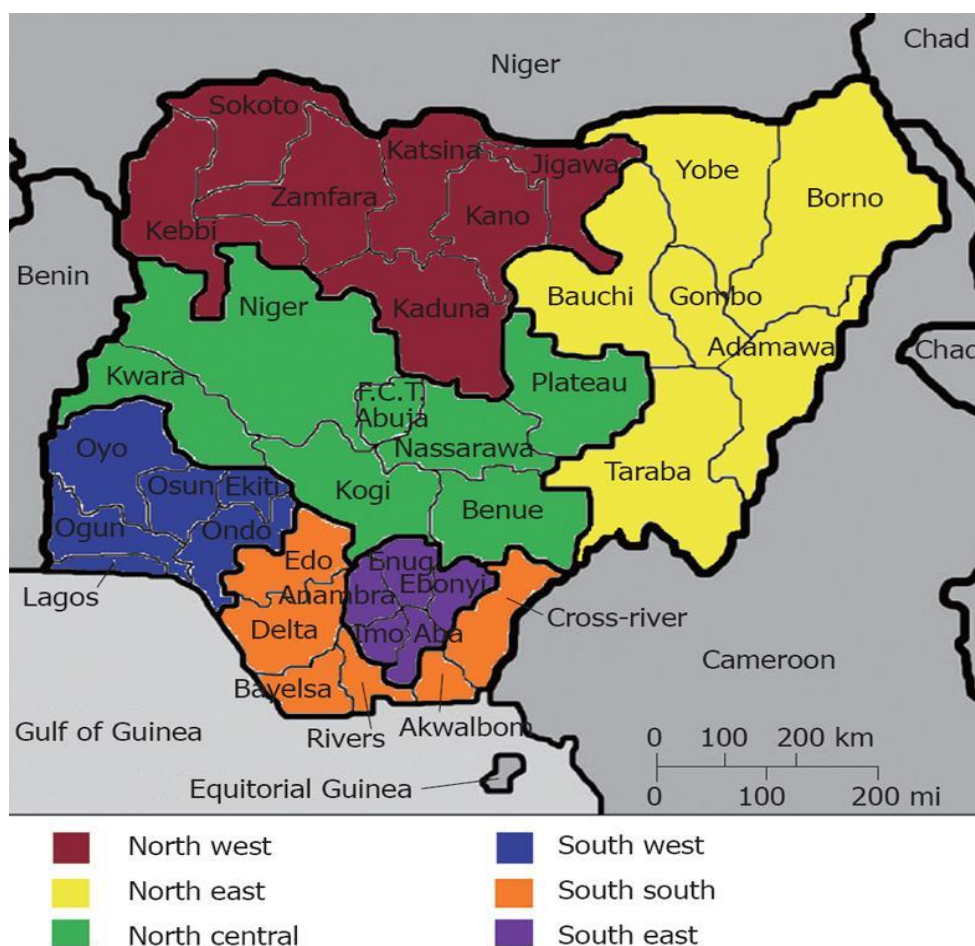


Figure 1.1: Six Political Zone Map of Nigeria Showing the Study area as South south region (Source: World Journal Cardiology, 2012)

This study focuses on Strategic Use of GIS for Oil and Gas Industry. The method adopted in this study is qualitative study where literatures were reviewed through the archival records, newsletters, journals, books, official documents and maps that include Topographic Map, Land use Map and Existing Pipeline Map. The maps were processed in a GIS environment using ArcGIS 10.2 software. Utilization of GIS tools for strategic applications in the downstream sector of oil and gas industry (especially in controlling vandalism) will be demonstrated. The evaluation will be based on descriptive statistics as well as spatial and attribute query. However, there are also some inadequacies of some information due to the fact that most of the existing base maps as well as the map showing the current situation of the existing pipeline routes are in small scale.

1.6 Significant of the Study

Oil and Gas Industry is the major industry and is critical to the economy of most countries across the globe. The use of GIS technology will be highly beneficial to the industry. Specifically, the outcome of this study shall serve as a guide to the choice of particular concept of GIS tool in taking certain technical decision in the issue vandalisation.

However, it can also serve as a guide to Nigerian National Petroleum Cooperation in dealing with the case or areas that experience reoccurrences of vandalism in the study area.

1.7 The Study Area:

The study area is in Delta State of Nigeria as illustrated in Figure 1.2.



Figure 1. 2: Nigerian map Showing Delta State

(Source: World Journal Cardiology, 2012)

1.7.1 General Information about Nigeria

Nigeria is a West African and federated country, comprising of 30 states and plus Abuja as federal capital territory and round the country they are 774 local governments (Toulmin, 2009). Its landmass covers 932,769 square kilometers and the country is bounded to the West by Benin republic, to its North Niger and Chad republic, west via republic of Cameroon and to the South by Atlantic Ocean. It gained its independence from the Great Britain (United Kingdom) on 1st October 1960. Its time zone is in the GMT + 1 time zone, however it is one hour ahead of Greenwich Time.

1.7.2 Vegetation, Seasons and Climate

Nigeria lies between the equator and the Tropic of Cancer. The climate of Nigeria varies from tropical region along the coastal area to the subtropical along the northern region or area. The southern part of the country is mainly tropical rain forest and mangrove swampy area towards the Niger Delta region. The vegetation in the North is thin, because of its transition from rain forest to Sahel Savannah from the peripheries of the Sahara desert.

There are two major seasons in the country, which include dry season, its duration lasting from November to March and the rainy season from April to October. Temperature in the coast rarely goes above 32°C, however humidity can be as high as 95%. In the extreme North the climate is dry with occasional sand storms; the temperature is ranging from 12°C to 36°C. At times during the rainy season, tropical thunderstorms occur periodically, most specifically in the coastal areas, but generally a time of cooler temperatures and climate (Toulmin, 2009).

1.7.3 People and Groups in Nigeria

Nigeria is in West Africa and the most populous black man nation in the world and has a population of over 140 million people 2006 Census, figures records (Adele, 2009). Nigeria is blessed with vast and abundant of mineral or natural resources and as well as human resources. The country has more than 250 ethnic groups or tribes and each of these ethnics have deferent dialects. Members of each tribal group are concentrated in one geographic location or the other. Figure 1.3 shows the study areas in detail.

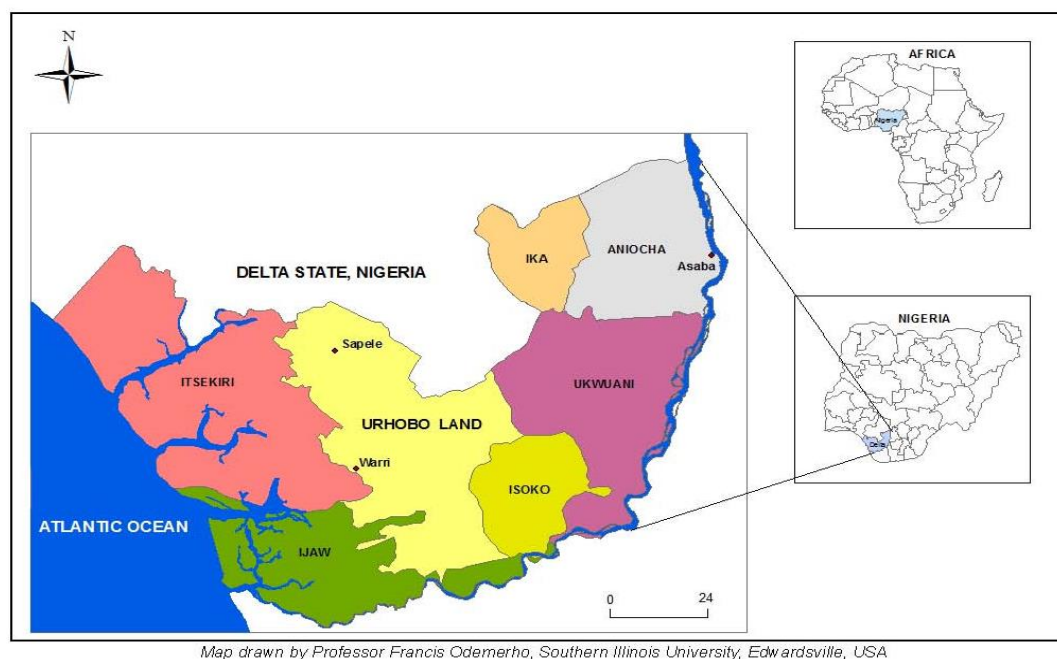


Figure 1.3: Map of Delta State of Nigeria Showing Study Area.

(Source: Delta State Government, 2008)

1.7.4 General Information about Delta State

Delta State is one of the states in Nigeria, derived its name from delta as a feature of the river Niger. The state was carved out from former Bendel State in the

year 1991. The state has 25 numbers of local government areas. Its capital city is called Asaba while, Warri is known as the biggest commercial nerves city in the state. The additional major towns are; Agbor, Ughelli, Sapele, Oghara, and Ogwashi-uku. Delta State shares boundaries with Anambra, Bayelsa, Edo, Ondo and Imo states respectively. In the south west and south it covers approximately 122 km of the coastline and bounded by the Bight of Benin on the Atlantic Ocean (OE, 2007).

1.7.5 People and Groups In Delta State

Delta State has diverse ethnical groups and various languages spoken around the state. In the North of the state comprises the Asaba (Delta Ibo), Aniocha, Ika, Ukwuani and Ndoisimili regions, the Delta Central and Delta South is made up of Urhobo, Ijaw, Isoko, and Itsekiri. Their Major ethnic groups are Urhobo, Igbo, Ezon, Isoko and Itsekiri (Alagoa, 1999).

1.7.6 The Soils

The soils types of Delta State are all of fluvial origin, apart from for the Coastal Barrier Islands which comprise of marine sand that overlain by an organic surface layer. The constant movement of delta's creeks has caused in a mosaic of the soil types. Remains of old levees contain regularly of water permeable sand and soil loam. However, the soil of the despairs behind them (Back Swamps) contain mostly of water-logged by heavy clay enclosed by peat, though higher lying sections comprise of salty loam and clay soils respectively (Alagoa, 1999).

1.7.7 The Climate

The climate of Delta State is categorized by a long duration of rainy season starting from March-April and through October. Precipitation intensify or increases from the north part of the delta (with an average of about 2,500 millimeters) in the coastal area where the mean annual rainfall in average is around 4,000 millimeters, that reason make it to be one among the wettest areas in African continent. In July the wet season peaks up, and January and February are the only dry months in the state. Though, even for the duration of this dry season there is an average monthly mean of about 150 mm rainfall that is recorded in the state. Relative humidity hardly dips less than 60% and fluctuates in the middle of 90% and 100% for almost throughout the year. At the time of the most of the rainy period cloud cover is almost continuous resulting in about 1,500 mean annual of the sunshine hours and also an average temperature per annual of approximately 28°C (Alagoa, 1999).

1.8 Summary

This chapter discussed about oil and gas industries in relation to vandalism in southern part of Nigeria. The aim and objectives, scope of the study area are also discussed. However, in Chapter 2, related literatures were reviewed which includes; oil and gas industry and it major activities, vandalism, its actors and effects in Nigeria, and GIS in controlling pipeline vandalism and many more concerning the study. While in Chapter 3, the methodology adopted are included the database design (Conceptual, Logical and Physical) of the existing petroleum pipeline as well as vandalism locations. Chapter 4 is about the discussion of the analysis which involves: Hotspot Analysis, Kernel Density Analysis, Proximity Analysis (Buffer Analysis, Select By Location and Near analysis), Hyperlink, Analysis, showing the high incidents of vandalism location, year of occurrences and total numbers of actors. Finally, the study ends up in Chapter 5 with conclusion remarks and recommendations.

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