

# Geospatial Techniques in Nigeria's Oil and Gas Sector: Applications and Impacts

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## Abstract

This study reviews the role of geospatial techniques in enhancing operations across the upstream, midstream, and downstream segments of Nigeria's oil and gas sector. Using a desk review of relevant literature, the paper highlights how Geographic Information Systems (GIS) and remote sensing improve exploration accuracy, optimize asset and pipeline management, and support environmental monitoring and protection. Findings show that these techniques have contributed to more efficient decision-making, cost reduction, and sustainability in the sector. Despite their proven benefits, adoption remains limited among operators in Nigeria. The study recommends wider integration of geospatial technologies, alongside capacity building and infrastructure development, to strengthen efficiency, safety, and environmental compliance in the industry.

**Key Words:** *Geospatial techniques, Oil and Gas, Remote sensing and Geographic Information System.*

## 1. INTRODUCTION

The oil and gas sector is a significant contributor to the Nigerian economy, accounting for a substantial portion of the country's revenue. However, the sector faces several challenges, including inefficient exploration and production, pipeline vandalism, and environmental degradation. The oil and gas industry operates in a highly dynamic environment where timely and accurate information is critical for decision making. The industry is characterized by complex operations, spanning exploration, production, transportation, and distribution. Operating in such a dynamic environment demands timely and accurate information to ensure operational efficiency, safety, and environmental compliance. (Kirti Vesdev, 2024). The industry plays a key role in the Nigerian economy. Despite plans to transition to renewable energy sources, most businesses are still heavily dependent on oil and gas products.

Geospatial techniques refer to the use of geographic information system (GIS), remote sensing, and other technologies to analyze and interpret spatial data. These techniques enable the collection, storage, analysis, and visualization of data related to the earth's surface. Geospatial techniques, including Geographic Information Systems (GIS) and remote sensing, have the potential to address these challenges, optimise exploration, production and transportation of oil and gas and improve the efficiency and sustainability of the sector. Geographic Information System (GIS) technology is being introduced into the petroleum industry has led to fast modifications and enhancements in the energy sector of the economy' activities in terms of evaluation, exploration, production, and product transmission from the depots to customers. (Yusuf et al., 2022).

Moro et al., (2023), revealed that the application of a Geographic Information System (GIS) is an effective alternative to optimize long-term solutions during oil and gas activities. In the research a desktop review was carried out to ascertain the global oil and gas operations and applications of GIS. Findings from this research reveal that due to the complexity and incertitude of quantifying technological risks, some oil companies prefer to

deploy technologies that are easy to manipulate and have a high record of successful applications with well-established risk profiles. The paper, therefore, concludes that GIS enhances intelligence and efficiency in oil and gas recovery, which in turn helps operators maximize production. Although, a lot of research were conducted to monitor and study oil and gas activities in Nigeria, many industries and agencies fail to apply these golden techniques despite its usefulness. This paper explores the impact of Geospatial techniques application across the upstream, midstream, and downstream in the oil and gas sector of the Nigeria economy.

## 2. THE STUDY AREA

Nigeria is in Western Africa, between longitudes 3 and 14 degrees and latitudes 4 and 14 degrees. It covers 923,768 square kilometers of land. Nigeria has a multi-cultural geography, with condition from dry lands to humid equatorial. Its most diversified feature, however, is its people. Among the multitude of languages and dialects are Hausa, Yoruba, Tiv, Edo, Igbo, Ibibio, Fula and English. The country is rich in natural resources, exceptionally large deposits of oil and natural gas. The nation's 800 kilometers of shoreline endows it with maritime power potential. Nigeria has an abundance of land for farming, industrial production, and commercial activities. Nigeria is bordered by Benin Republic to the west Niger Republic to the north, Cameroon and Chad to the east and the Atlantic Ocean's Gulf of Guinea to the south. Nigeria is not only the largest country in Africa, but it is also the most populous (Ajayi, et al., 2022).



Figure 1: Map of Nigeria.

### **3. METHODOLOGY**

This research paper uses a qualitative method of research to examine the impact of geospatial techniques in the oil and gas sector of the Nigerian economy. The methodology adopted in this study is the use of desk review of science journals, publications and seminars.

### **4.0 RESULTS**

The results of the survey show that geospatial techniques are being used in various aspects of the oil and gas sector in Nigeria, including exploration and production, pipeline management, and environmental monitoring. The results also show that the use of geospatial techniques has had a positive impact on the sector, including improved efficiency, reduced costs, and enhanced environmental sustainability.

#### **4.1 Oil and Gas Exploration**

The application of Geospatial techniques in exploration enables the identification of potential hydrocarbon reservoirs, optimization of well placement, and seismic planning. These techniques facilitate the analysis of spatial data, allowing for more accurate predictions and decision making.

##### **4.1.1 Geological Mapping**

Geospatial techniques create detailed maps, enabling geoscientists to understand the subsurface geology and identify potential exploration targets. (Yusuf et al., 2023), Used Satellite RS and GIS to produce a predictive hydrocarbon resource map of the Chad sedimentary Basin. In their study, remote sensing and GIS were integrated and used for specific geological data classes. Satellite RS techniques cover a wider area of coverage for hydrocarbon exploration and give a precise location of predictive areas using certain parameters such as elevation and lithology. This technique is faster and less costly, unlike other techniques. It involves the use of field and laboratory spectral data in organizing remote sensing products. With multispectral scanners from orbiting satellites, the study used an elevation model and lithological map to identify the possible location of hydrocarbons within the Chad basin in Nigeria. Their results show that nine local government areas are liable to have a

high concentration of hydrocarbon deposits at a commercial quantity. Only three local governments so far that was undergoing full exploration.

##### **4.1.2 Seismic Data Interpretation**

Geospatial techniques help interpret seismic data, identifying potential hydrocarbon reservoirs and optimizing exploration targets. It is a well-known fact that in oil and gas exploration, seismic surveys are used by many organizations to map geological structures beneath the earth's surface or beneath the seabed (Nanda, 2021; Mohammadpoor and Torabi, 2020; Xishuang et al., 2014). However, reflection seismology is commonly used during onshore exploration and involves sending seismic waves underground. Very few studies were conducted on the use of digital elevation models and surface lithology to predict the possible deposit of hydrocarbons. In most research, elevation models for hydrocarbons exploration were primarily used for well drilling and seismic attributes (Zhang et al., 2022; Djeddar et al., 2022); whereas surface lithology was mainly used to detect the hydrocarbon seepage (El-Hadidy et al., 2022; Cvetković, et al., 2021; Lord, 2017).

#### **4.2 Asset Management**

Geospatial techniques support asset management, enabling operators to optimize resource allocation, reduce cost and improve decision making, it helps manage physical assets, such as pipelines, wells, and pump stations. This can be done by storing, collecting and managing the physical location of such features, this enables the companies to make informed decisions about maintenance, repairs, and resource allocation. This was well stated by (Shahabi et al., 2015), when he said that GIS can be used as a strategic tool for control and proper management of vandalisation problems.

##### **4.2.1 Transportation and pipeline management**

The techniques optimize pipeline routes, reduce costs and environmental impacts, monitor pipeline condition, detecting potential leaks and anomalies and enable proactive maintenance. This, however, was observed by (Yusuf et al., 2022), in their study using GIS, they created digital maps of petroleum depots, oil and gas pipelines, and other relevant

features such as Temperature, soil types, vegetation, and terrain. Pipeline attributes such as pipeline coating, thickness, diameter, maintenance information and date of installation were used to create a relational database model. The queries operations on the database depict the essential information, such as the next date of pipe maintenance, sabotage-prone areas, and locations with specific pipe diameters. Part of the maps presented in the study includes the Temperature, elevation, soil, and rainfall maps. This was produced to determine how they will affect the location of the pipelines to aid decision making. To further explain the impact these techniques had on asset management an investigation for the potential use of GIS as a strategic tool for the oil and gas industry for controlling pipeline vandalism in Delta State was made by (Sani et al. 2016). In the study, Kernel density mapping was used to describe four locations which were identified as hotspots for crime. Buffer analysis and multiple ring buffer analysis were used to create area features at stated or specific distance or numerous distances around the chosen input features. Further, the spatial joint was used to show the nearest facilities according to distance like the hospital, police station, and fire station within the study area from vandalism or pipeline buffer. The investigation revealed that GIS technology can be used to analyze crime incidents of vandalism by showing the hotspots of vandalism, pattern and trends of incidents and proximity of the settlements to the incident points to control the petroleum pipeline vandalism areas (oviri) in the Delta State of Nigeria.

#### **4.3. Environmental management and Protection**

Geospatial techniques can be used to monitor environmental changes, tract subsidence caused by resource extraction, and identify potential geo-hazards. It can also be used to respond to emergencies such as oil spills and gas explosions. This enables companies to develop effective mitigation strategies and minimize environmental impacts. ESIM Technologies (2024) explained that responsible reservoir management includes minimizing environmental impacts. This involves monitoring for potential leaks, spills, and other

hazards, as well as implementing measures to mitigate environmental damage. A study to evaluate the environmental impact of the oil industry on the Niger Delta was conducted by comparing Landsat satellite images from 1985 to 2000 using unsupervised classification techniques. The results highlighted a decline in water bodies and mangrove forests, illustrating the impact of oil spills in the region. (Twumasi & Merem 2016). Further to explain more on the impact of geospatial techniques on environmental management and protection in oil and gas industry, (Uchegbulam & Ayolabi 2013) studied environmental degradation in the Western part of the Niger Delta, using NDVI analysis on Landsat images from 1987 and 2002, they concluded that the decrease in NDVI values between these dates indicated land degradation due to hydrocarbon exploration and human activities.

#### **5.0 CONCLUSION**

The application of geospatial techniques in the oil and gas sector of the Nigerian economy has the potential to significantly improve the efficiency and sustainability of the sector. The results of this research paper show that geospatial techniques are being used in various aspects of the sector and are crucial for efficient exploration, production, and transportation of oil and gas. Their use has had a positive impact on both the upstream, midstream and downstream operation. Therefore, it is recommended that oil and gas companies in Nigeria continue to adopt and apply geospatial techniques to enhance their operations and contribute to the sustainable development of the sector.

#### **6.0 RECOMMENDATIONS**

The following recommendations can damage the uptake and usage of Geospatial technology in the oil and gas sector, enhancing their operations and contributing to the sustainable national development:

- I. Capacity building and training programs to enhance the skills and knowledge of oil and gas professionals in the application of geospatial techniques.
- II. The development of infrastructure, such as satellite imagery and GIS software, is

necessary to support the application of geospatial techniques in the oil and gas sectors.

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