

An Assessment on the Effect of oil Spillage on Mangrove in Parts of the Niger Delta Region of Nigeria Using Geospatial Technology

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Abstract: The continuous seepage of oil due to poor management practices has led to increased decline in the mangrove forest. Oil spillage causes acute toxicity hereby intensify the influence of physical asphyxiation on the mangrove tree. The people residing in the study area are faced with challenges generated from oil spillage which has degraded their farmland, making it unsuitable for agricultural practices. Rivers are being contaminated with oil making the aquatic environment unbalanced. This has greatly affected the dwellers within this region of the Niger delta as major source of income and means of livelihood are being endangered, thereby increasing the rate of poverty in these region. A spatiotemporal mapping was done to evaluate the extent of damage on the mangrove and the current status. Therefore the paper is aimed at evaluating the extent of the damages caused by oil spillage to mangrove vegetation from 2002 to 2015 and also recommend solutions to curtail these damages. Spatiotemporal land use land cover (LULC) analysis was done to classify and map the variables using remote sensing and geographical information system (GIS) technique. Landsat TM image for 2002 and 2015 were used to evaluate trends, magnitude, and annual rate of change LULC for the study area. This study reveal that mangrove had decline over the years. Results of evaluated LULC change, assessment of shoreline dynamics, as well as the indicator of oil exploitation activity were observed within the 13 years' time span.

Keywords: Mangrove Vegetation, GIS, Change Detection, oil spillage.

I. INTRODUCTION

The mangrove swamp forest is mostly found on the coastland and it is justly extensive in sheltered coastline. The mangrove is composed of plant species which has special adaptive characteristic enabling them to survive the variable flooding and salinity stress conditions enacted by the coastal environment. Mangroves are taxonomically diverse group of salt-tolerant, mainly arboreal, flowering plants that grow primarily in tropical and subtropical regions (Ellison and Stoddart 1991). A "mangrove" has been defined as a "tree, shrub, palm or ground fern, generally exceeding more than half a meter in height, and which normally grows above mean sea level in the intertidal zones of marine coastal environments, or estuarine margins" (Duke 1992). The term "mangrove" can refer to either the ecosystem or individual plants (Tomlinson 1986). Mangrove ecosystems have been called "mangals" (Macnae 1968) to distinguish them from the individual plant species.

Located along the coastline, Nigeria mangrove vegetation are characterised by *Laguncularia racemose* commonly called White mangrove and *Rhizophora mangle* commonly called Red mangrove which are tall woody trees. They are characterised by aerial roots, they have height of 50 m

and a girth of up to 2.7m in the drier outer margins of the mangroves. The mangrove have evergreen broad leaves and some raffia palms. Mangroves enhance soil formation, shoreline protection, and stabilization along the coastline.

The mangrove forest is extensive, above-ground root structures (prop roots, drop roots, and pneumatophores) act as a sieve, reducing current velocities and shear, and enhancing sedimentation and sediment retention (Carlton 1974; Augustinus 1995). Mangrove enhances sedimentation, sediment retention, and soil formation, mangroves stabilizes soils, which reduces the risk of erosion, especially under high-energy conditions such as tropical storms. Mangroves provide both habitat and a source of food for a diverse animal community that inhabits both the forest interior and the adjacent coastal waters. Mangrove habitats maintain water quality by trapping sediments in the mangrove root system, these and other solids are kept from offshore waters, thereby protecting other coastal ecosystems such as oyster beds, seagrasses, and coral reefs from excessive sedimentation (Carlton 1974; Augustinus 1995). Raffia palm found in the mangrove are used in making baskets, source of local wine, Bags, brooms, cane chairs and roofing, boat building, firewood and props in the lumbering industry. Swamp rice cultivation is also important. Mangrove vegetation is a very important plant most especially with the tropics and sub-Saharan Africa, however these vegetation have been treated with less priority and importance. Concern about the magnitude of loss of mangrove forests has been voiced mainly in the specialized literature (Saenger et al. 1983, Spalding et al. 1997).

Nigeria economy is based on crude oil exploration and this has been of great benefit to Nigerian, but anthropogenic activities have endangered the mangrove forest, some of the activities that have imperiled the mangrove include oil spillage from mining activities, landuse conversion of mangrove to agricultural landuse, industrial land use, urbanization, Mari culture etc. Oil spillage has being a trend issue since the inception of crude, it is the most commonly debated of all the environmental impacts of oil exploitation. Constitutional Rights Project (CRP, 1999) defines oil spills as uncontrolled releases of any product relating to oil production including crude oil, chemicals, or waste caused by equipment failure, operation mishaps, human error, or deliberate destruction to facilities. According Adewuyi (2001), Oil spillage occurs during the drilling of oil wells and as a result of oil pipelines leakages and during the loading of oil into the tankers. Spills are potentially the most devastating on agricultural land and water resources. UNDP (2006) reports that much of the environmental pollution in the oil-producing areas is as a result of oil spillage, essentially by accidents based on human error and equipment failure. Orubu *et al.*, (2004) share this view when they reported that massive oil spills occurring in the riverine areas have done

untold damage to the aquatic ecosystem, particularly in the mangrove swamp forest zone.

The people residing within these communities have made series of complains about the negative effect of oil spillage on their mangrove forest, and even surface water and ground water system. Oil spillage has led to the deprivation of mangrove. Spill makes the ecosystem unstable. Large areas of mangrove forest have been destroyed over a wide area, affecting terrestrial and aquatic habitat. Mangroves are highly vulnerable to oil exposure. Acute effects of oil (mortality) occur within six months of contact and usually within a much shorter time frame (a few weeks) after which the mangrove leave begins to turn yellow, defoliation, and tree death. More subtle responses include branching of pneumatophores, germination failure, decreased canopy cover, increased rate of mutation, and increased sensitivity to other stresses (Rebecca Hoff et al., 2014). Hencethis paper aims to evaluate the extent of damage caused by oil spill to vegetation between 2002 and 2015, recommending solutions to curtail these damages.

II. STUDY AREA

The study area is Ilaje Local Government Area in Ondo State, Nigeria. Ilaje Local Government Area of Ondo State lies roughly between latitude 6°00'N and 6°20' N and

longitude 4°45' E and 5°45' E. Its approximate northern boundaries are around Ikale and Arogbo-Ijaw in the Okitipupa and Ese-Odo Local Government Areas of Ondo State. In the southern boundary is the Atlantic Ocean whereas it is bordered in the west by Ijebu in Ogun State, the eastern boundary is the Itsekiri land in Warri, Delta State. It has a coastline of about 180km thus making Ondo state, the state with the longest coastline in Nigeria. Some of the other towns and villages include Ugbo, Mahin, Ayetoro, Araromi, Mahintedo, Ubale Kekere, Ubale-Nla, Ilepete, Atijere, Ikorigho, Ode-Ugbo, Awoye, Molutehin, Okesiri, Obe Nla, Ilowo Zion, Orotu, Igboegunrin, Igbokoda-Zion, Igbokoda (LGA headquarter), (ERA 1999). The major occupation of thellaje people are fishing, canon and boats building, commercial water transport, trading activities include mainly fishes, woven material, distilled locally made gin. The administrative nerve centre of Ilaje at Igbokoda is primarily mangrove swamp forest. Major rivers into which secondary watercourses from swamp areas flow dominate the entire areaERA (1999). Crude oil is concentrated in the Ugbo subgroup area, while some communities in the Mahin and Aheri subgroups feel the impact of oil exploitation but are not oil producing.

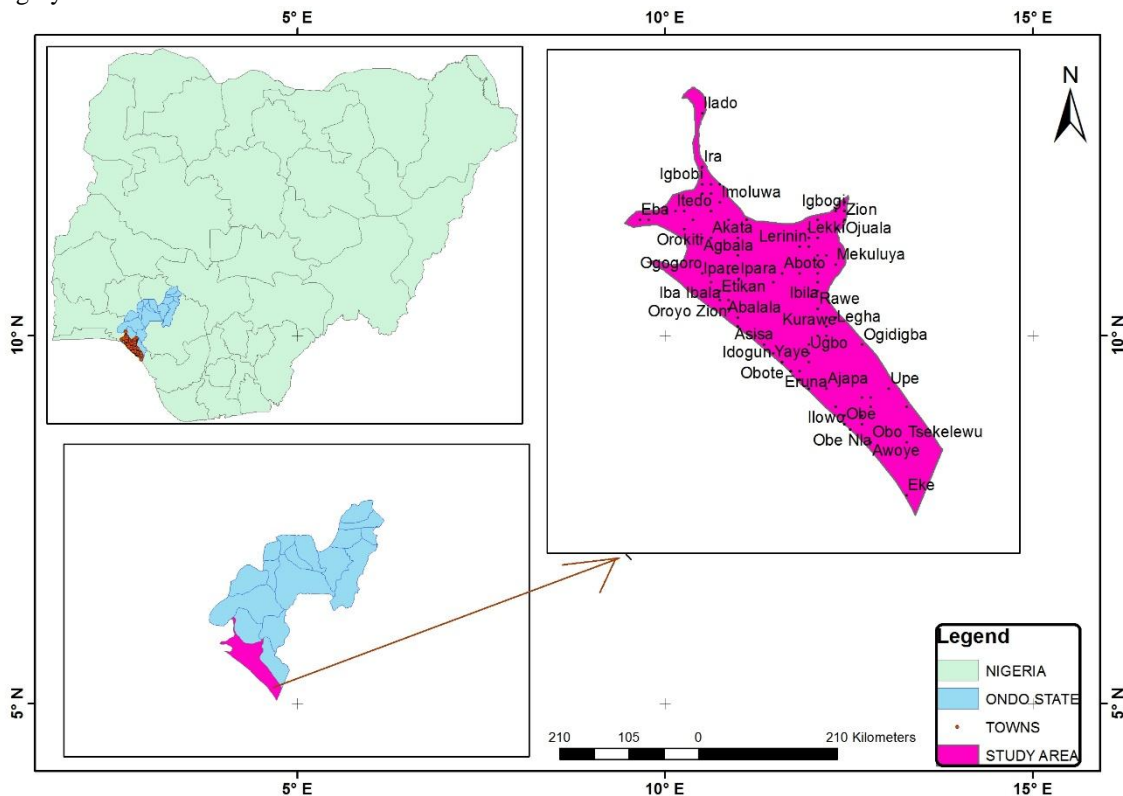


Figure 1 : STUDY AREA MAP

III. MATERIALS AND METHODS

This study is based mainly on satellite image data that is acquired from Landsat Thematic Mapper. (Landsat 5 and Landsat 8). Satellite image 2002 and 2015 was downloaded from the United States Geological Survey. Six different variable were identified, theses includes human settlement, Agriculture, swamps, healthy forest, degraded forest, waters bodies. The data matrix was designed for year 2002 and 2015.

IV. THE GEOSPATIAL DATA PROCESSING ANALYSIS

The Landsat TM for 20 December 2002 and 16 December 2015 were obtained for the study area. The Landsat TM were processed using the image processing software and ArcGIS 10.2. The images were imported to the ArcGIS environment in GEOTIFF format the Landsat satellite imagery 2002 and 2015 Ilaje were geo referenced. A false colour composite was generated using 3 bands, 2002 combined 432/RGB and 2015 imagery 543/RGB combination was used. Six variable were identified using supervised classification to classify the variable. Both images were projected to the

Universal Traverse Mercator (UTM) coordinates zone 31. The spheroid and datum was also referenced to WSG84. The digitalized map was then used to extract the region of interest for study for both years i.e. 2002 and 2015 respectively. The subset of study area 1441638.18 hectare.

The first set of result landuse landcover LULC data was to generate the change analysis different multi temporal land use landcover statistic. Change analysis was performed by overlapping the difference multi temporal land use and landcover statistic followed by identifying the magnitude, trend and rate of change between 2002 and 2015. The magnitude of change was calculated by deducting the area covered by the previous year from the initial year.

$$\begin{aligned} & \text{magnitude of change} \\ & = \text{magnitude of change of the initial year} \\ & - \text{magnitude of change of the previous year} \end{aligned}$$

magnitude of change of the previous year.

Each variable magnitude of change is then divided by the sum of change multiplied by 100 to calculate the previous change.

$$\text{Percent of change} = \frac{\text{magnitude of change}}{\text{sum of change}} \times 100$$

Annual rate is then calculated by percentage of change divided by 100 multiplied by the difference interval between study period i.e 2002-2015 (14)

$$\text{Annual rate of change} = \frac{\text{percent of change}}{100} \times \text{interval between study period}$$

V. RESULT

The overall land cover change for the duration of 13 years, between year 2002 – 2015 is given in table below:

Table 1: LULC Statistics for 2002 AND 2015

CLASSES	AREA (ha) 2001	PERCENTAGE	AREA (ha) 2015	PERCENTAGE
WATER BODIES	2677.11	1.9	1929.62	1.3
SWAMP	21303.27	14.7	24846.21	17.2
HEALTHY FOREST	101417.44	70.1	55489.83	38.4
BUILT UP	10147.79	7.0	5284.5	3.7
DEGRADED FOREST	9101.96	6.3	57088.02	39.5
GROUND TOTAL	144647.57	100	144638.18	100

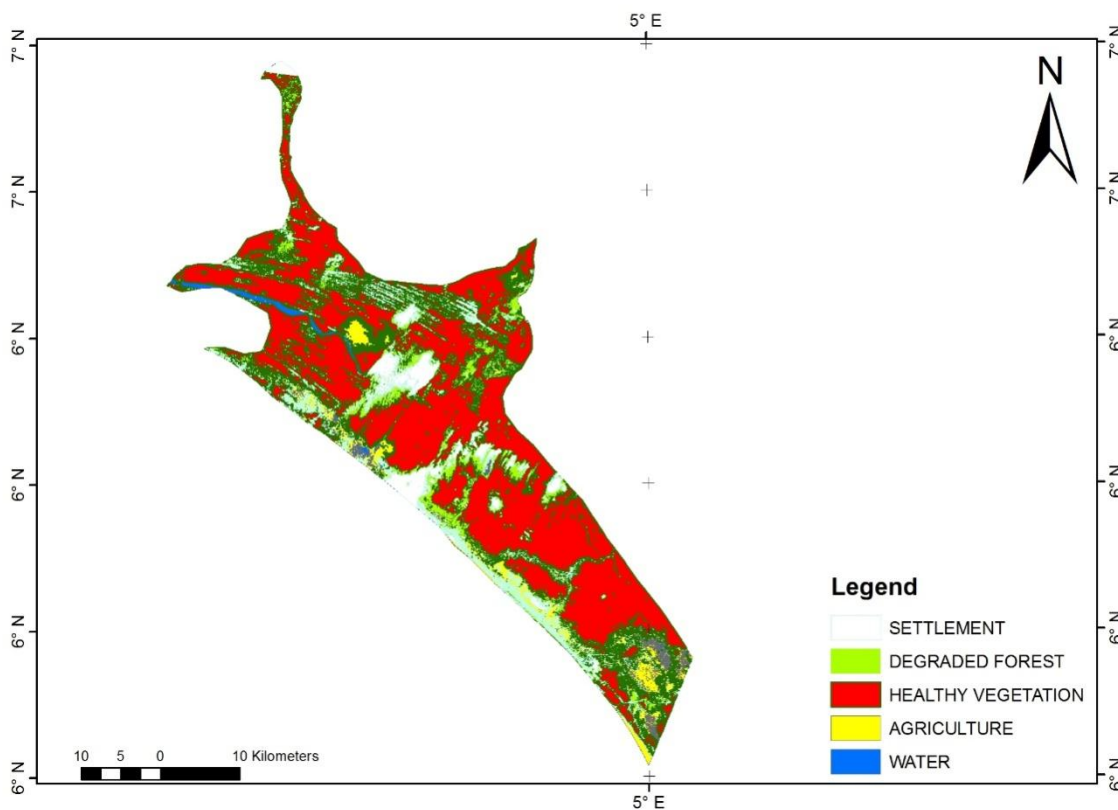


Figure 2: Landuse-landcover 2002

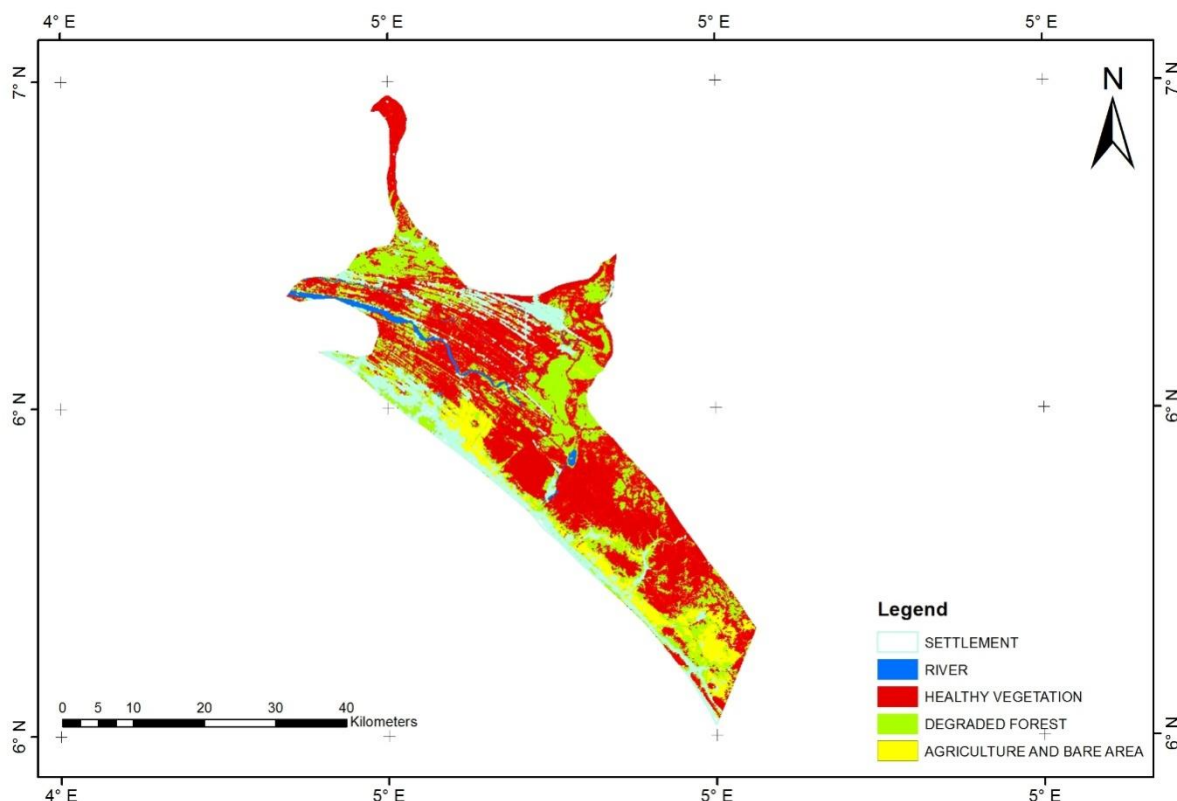


Figure 3: Landuse-Landcover 2015

CLASSES	2002-2015 Change		
	Magnitude (Ha)	Trend	Annual Change rate
WATER BODIES	-747.49	-16.23	-2.27
SWAMP	3542.94	7.68	1.07
HEALTHY FOREST	-45927.61	-29.27	-4.10
BUILT UP	-4862.50	-31.51	-4.41
DEGRADED FOREST	47986.06	72.50	10.15

Table 2: 2002-2015 Change Magnitude, Trend and Annual Rate

From the figures 2 and figure 3 water bodies declined from 2677.11 (1.9%) in 2002 to 1929.62 (1.3%) in 2015 agriculture increased from 21303.27 (14.7%) in 2002 to 24846.21 hectare to in 2015. There was a massive decline in the healthy vegetation in 2015 with 55489.83 (38.4%) hectare compared with 2002 with 101417.4 hectare. The built up area increased to 5284.5 ha due to construction works undertaken by Niger Delta development commission NDDC and most especially state oil producing area development commission (OSOPADEC). Area covered by degraded forest has increased by 57088.02 (39.5%) ha compared to previous year of study that was 9101.96 ha (6.3%). This degradation was due to the indiscriminate felling of mangrove tree resulting to decline in percentage of wet lands in the area of study.

CONCLUSION

This paper demonstrate the potential of remote sensing method in identifying and mapping oil spill effect in the study area. The study reveals a drastic decline in the landmass covered by mangrove vegetation and fresh water swamps, this is due to poor management of oil wells, pipelines and tankers, oil spillage has had a devastating effect on this location. The result of this study is an indicator, to what may be going on in other areas where crude oil theft is high and rampant .The result

of the study also support previous work that has been done in the past on the study area. Oil spillage could be hazardous to aquatic habitat, as their habitat are being polluted and fishes may not survive in this condition. Oil exploitation and exploration causes deterioration of coastal environment most especially mangrove forest. It is hereby recommended that the Federal government should revise enacted laws, regulations, standards that will control the oil companies with regards to proper management of the production process within and out of oil firm facilities and ensure proper enforcement. There should be constant monitoring of oil firms and pipelines so as to identity locations where the oil bunkering has taken place and replace damaged pipelines. In addition the oil tankers should be maintained regularly to avoid leakages, crude oil companies should be mandated to employ qualified personnel. Companies should also perform their social responsibilities to the people affected by oil spillages by compensating them on the damages done to their land. Environmental Impact Assessment should be constantly carried out to audit the activities of these oil firms.

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