Use of Remote Sensing Data to Detect Environmental Degradation in the Oil Rich Region of Southern Nigeria between 2003 and 2015

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Abstract—*The oil spill management system aims to achieve a knowledge- based system which can choose the most suitable method of response in shorter time by analyzing the various sensitivity factors of coastal environment, affecting parameters on oil spill movement, environmental concerns in oil spill response, and consequent monitoring and clean-up measurements. The major advantage of this integration is the ability to extract oil spill parameters such as location, linear size and spill areas. Spatial and temporal information, i.e. oil spill distribution at the sea, its frequency and evolution in time allow the scientists to establish the major cause and source of oil spills, and then outline the risk areas. This study has demonstrated the application of GIS and remote sensing as a decision support tool for oil spill management. Its objectives are to perform image classification and accuracy assessment, to perform post classification change detection for oil spill detection and to perform trend of change analysis for oil spill growth trend. Methodology involves planning stage, data requirements, data acquisition, data processing and results presentation. The results indicated that the annual growth rate of water bodies is decreasing at -0.16% from 2003 to 2015, settlements decreased at a rate of -1.16% from 2003 to 2015 while Mangrove and vegetation decreased significantly at the rate of -2.82% and -1.92% respectively from 2003 to 2015, this is by far the most significant decrease in the study area, as oil spill degrades farmland and plantations there by rendering it useless for economical purposes, the results also indicated that degraded environment increased at a rate of 3.39% from 2003 to 2015. It was further recommended amongst others that further studies should be on oil spill management in Gokana L.G.A as this will provide additional information on how to manage the effects of oil spill in Gokana L.G.A.*

I. INTRODUCTION

Petroleum products play an important role in modern society, particularly in the transportation, plastics, and fertilizer industries, there are typically ten to fifteen transfers involved in moving oil from the oil field to the final consumer (Jha et al, 2008). Oil spills are serious environmental disasters, often leading to significant, long-term impacts on the environment, ecology and socio-economic activities of area. Oil spillage refers to the discharge of petroleum onto the surface of inland or coastal waters, comprehensively; it was defined by Adelana et al, (2011) as the release of liquid hydrocarbons (crude and refined oil) and petroleum by-products into the marine, coastal areas and other environments due to human activities. Oil spills can occur during the transportation or storage of the oil, and the spillage can happen in water, ice or on land (Jha et al, 2008). This implies that oil spillage is a form of pollution that has only anthropogenic (non-natural) cause. In Nigeria, commonly reported causes of oil spillage include pipeline leaks and burst due corrosion and pressure build up, sabotage and oil theft, tankers' accidents, human error due to poor training or laxity, poor and old infrastructures, and failure to meet standards practices and infrastructures. Most of the conflicts, environmental degradation and crisis going on in the Niger Delta region in Nigeria are attributable to poor or total absence of effective environmental management (Okotoni, 2004). The poor environmental management due to business practices in this area has resulted in social, economic and political problems and this have negatively affected the well-being of dwellers in this region. In Rivers state Nigeria, the analogue methods of acquiring information necessary for mitigating oil spills

and remediation are slow and inconsistent. There is lack of updated information and situational awareness that will enhance contingency plan in an event of spill. Many issues related to oil spill contingency planning and any emergency management has spatial dimension. There is need for a more efficient method that will speed up response time and save cost. Geographical understanding of the spillage will go a long way in devising ways to manage and control this spillage problem. It will also facilitate responds and therefore mitigate environment and economic damage caused by oil spill.

II. STUDY AREA

The study area, Gokana is a Local Government Area in Rivers State, Nigeria. Its headquarters are in the town of Kpor. It has an area of 126 km² and a population of 228,828 at the 2006 census.

The Gokana people have a rich cultural heritage. The main religions are Christianity and African traditional religions; although most of its customs, traditions and festivals have become extinct due to urbanization and rural-urban migration.
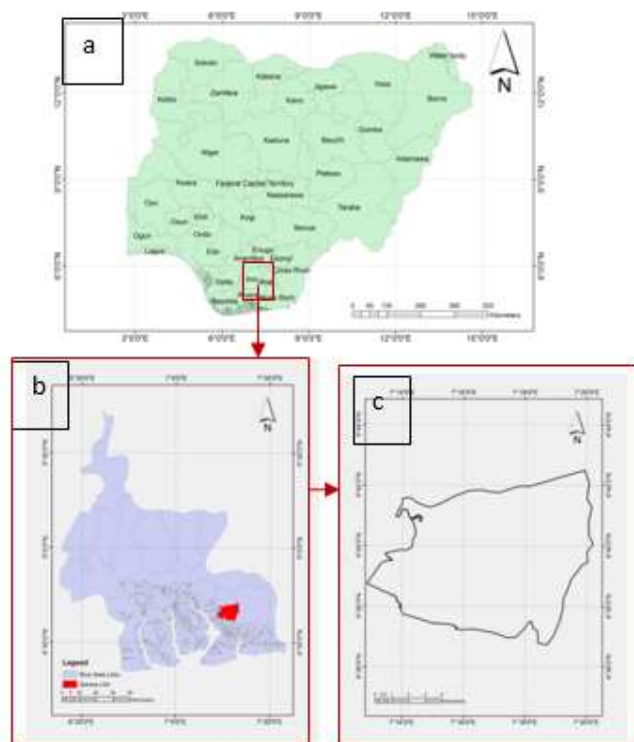

Fig.1 (a) Map of Nigeria (b) map of Rivers State showing Gokana L.G.A (c) Map of Gokana L.G.A

III. METHODOLOGY

For a proper and effective optimization, planning is very important. In this phase of the study, a user requirement analysis was done to focus on what information is presently being used, who is using it and how the source is being collected, stored and maintained. There is ideally a map of existing processes which was improved as well as being replicated by the GIS. The necessary information was obtained through interviews, documentations, reviews and workshops. This also involves the data requirement, hardware and software selections and method to be used.

3.1 Data Requirement

Data used in this research includes;

I. Landsat 7 ETM+ and Landsat 8 OLI Imagery of the study area
II. Co-ordinates of control points and other points of interest
III. Attribute Data of points of interest.
IV. Administrative map of Rivers State showing Local Government boundaries
V. Materials available in Academic journals, conference papers, relevant texts, brochures, internet and statistical files of government offices

3.2 Methods and Techniques

The method incorporated in this study involves image subset, remote sensing image classification techniques as well as spatio-temporal analysis of satellite imagery. Image subset was done on the two multi- temporal sets of images obtained (LandSat7 ETM+, LandSat8 OLI) in order to cut out the study area, after which land cover maps of the study area was produced using the supervised maximum likelihood classification algorithm in ERDAS Imagine used by (Onojeghuo and Onojeghuo, 2013). A post classification change detection technique was also employed to determine the changes that have occurred in the time period between 2003 and 2015 and trend analysis was performed to determine the trend of increase in the time period between 2003 and 2015.

IV. RESULTS

In this section, results of image analysis as obtained from the hard classification procedure of supervised (MLC) classification, change detection and trend analysis are presented. Most of the discussions are supported by maps, tables and illustrative graphs.

4.1 Land cover / Land use Distribution of Gokana L.G.A of 2003

In mapping landcover/land use, five different classes were identified to include Settlement, Degraded Environment,

Water, Vegetation and Mangrove. The classified image of Gokana L.G.A is shown in figure 4.1

The land cover/land use distribution of Gokana L.G.A in 2003 as shown in table 4.1 and fig 4.2 indicate that Vegetation and Settlement accounted for the largest land cover/use of about 34.22% and 27.89% respectively, with areas of about 8093 hectares and 6599 hectares. Mangrove with 18.84% and an area of 4455 Hectares is 3rd, and water body has the lowest with 9.30 % with an area of 2200 Hectares. The Degraded Environment had 9.75% with a total area of 2305 hectares.
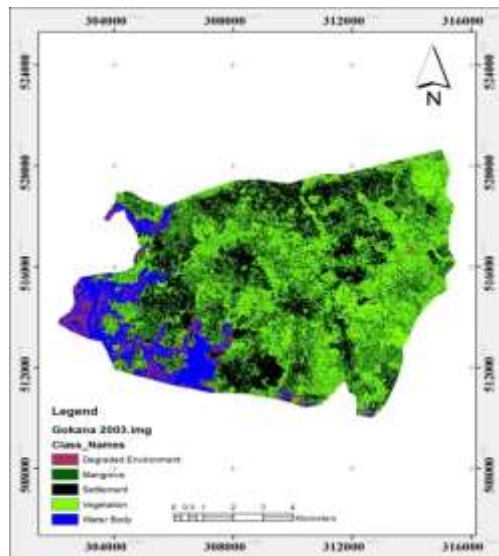

Fig.4.1: Landcover/Landuse classification of Gokana L.G.A of 2003

Table.4.1: 2 Landcover/Landuse distribution of Gokana L.G.A of 2003

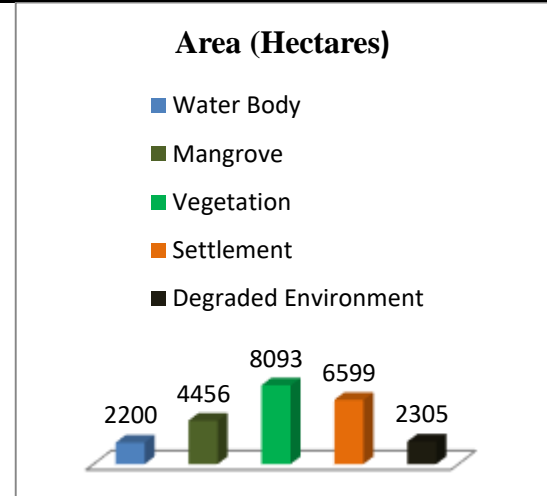| Class/Region	Area (Hectares)	Percentage (%)
Water Body	2200	9.30
Mangrove	4456	18.84
Vegetation	8093	34.22
Settlement	6599	27.89
Degraded Environment	2305	9.75
Total	23,653	100

Fig.4.3: Landcover Classification Image of Gokana LGA of 2015

4.2 Land cover / Land use Distribution of Gokana L.G.A of 2015

The land cover/land use distribution of Gokana L.G.A in 2015 as shown in figure 4.3, 4.4 and table 4.2 indicate that Settlement and Vegetation accounted for the largest land cover/use of about 41.85% and 21.53% respectively, with areas of about 9899 hectares and 50.53 hectares. Degraded Environment increased to 22.43% with an area of 5505 Hectares. Then water body and Mangrove had the lowest with 8.03% and 6.16% with an area of 1900 Hectares and 1456 Hectares respectively.

Table.4.2: Landcover/Landuse distribution of Gokana L.G.A of 2015

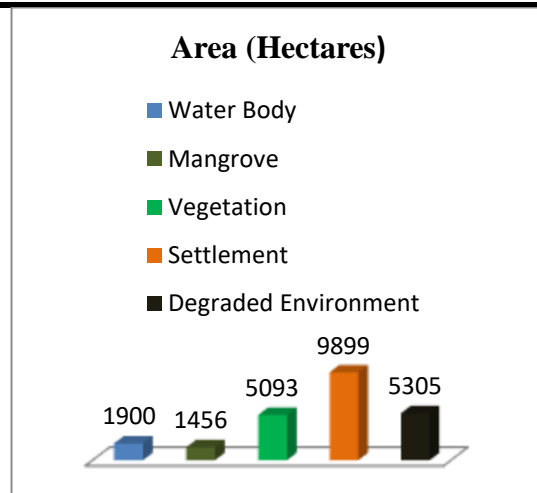| Class/Region	Area (Hectares)	Percentage (%)
Water Body	1900	8.03
Mangrove	1456	6.16
Vegetation	5093	21.53
Settlement	9899	41.85
Degraded Environment	5305	22.43
Total	23,653	100

Fig.4.4: Histogram of Landcover/Landuse of Gokana L.G.A of 2015

4.3 Change Detection in Gokana L.G.A between 2003 and 2015

The classified Landsat7 ETM+ of 2003 and Landsat OLI 2015 was used to generate figure 4.5 with the attributes presented in table 4.3
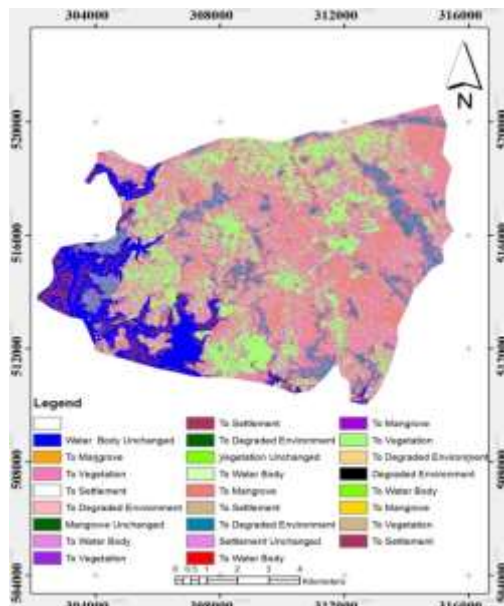

Fig.4.5: Change detection of Gokana L.G.A between 2003 and 2015

Table.5.4: Change detection distribution of Gokana L.G.A from 2003 to 2015

CHANGE DETECTION 2003 - 2015		
Class Type	Area (Hectares)	Percentage (%)
Water body Unchanged	1600	6.71

Water body to Mangrove	200	0.84
Water body to Vegetation	550	2.31
Water body to Settlement	600	2.52
Water body to Degraded Environment	1200	5.03
Mangrove Unchanged	1000	4.19
Mangrove to Water Body	150	0.63
Mangrove to Vegetation	300	1.26
Mangrove to Settlement	1400	5.87
Mangrove to Degraded Environment	1000	4.19
Vegetation Unchanged	4093	17.16
Vegetation to Water Body	110	0.46
Vegetation to Mangrove	185	0.77
Vegetation to Settlement	1200	5.03
Vegetation to Degraded Environment	500	2.09
Settlement Unchanged	6899	28.92
Settlement to Water Body	40	0.16
Settlement to Mangrove	71	0.29
Settlement to Vegetation	150	0.62
Settlement to Degraded Environment	300	1.25
Degraded Environment Unchanged	2305	9.66
Degraded Environment to Water Body	0.00	0
Degraded Environment to Mangrove	0.00	0
Degraded Environment to Vegetation	0.00	0
Degraded Environment to Settlement	0.00	0
Total	23853	100

From the data presented in table 4.3, it shows that degraded environment didn't lose any area from 2003 to 2015, but rather the other land cover features changed to degraded environment, this can be interpreted by saying that degraded environment increased over the years by gaining against other landcover features this is as a result of increased oil spillage from 2003 to 2015.

Although there was a bit of urbanization from the increase of settlements 2003 to 2015, the data shows that settlements also lost 1.25% of its area from 2003 to 2015 to oil spill events. Water body suffered the most loss with 5.03 % of its area lost to oil spillage, followed by mangrove, losing

4.19% of its area to oil spill, then vegetation with 2.09 lost to oil spill from 2003 to 2015.

Also from the data in table 5.4, Water body had a total unchanged area of 1600 hectares, losing 0.84% to mangrove, 2.31% to vegetation and 2.52% to settlement. Mangrove had a total unchanged area of 1000 hectares, losing 0.63% to water body, 1.26% to vegetation and 5.87% to settlement. Vegetation had a total unchanged area of 4093 hectares, losing 0.46% to water body, 0.77% to mangrove and 5.03% to settlements. While settlement had a total unchanged area of 6899 hectares, losing 0.16% to water body, 0.29% to mangrove and 0.62% to vegetation from 2003 to 2015.

4.4 Trend Analysis

The results of the trend analysis from the data presented in figure 4.6 and table 4.6, indicates that the annual growth rate of water bodies is decreasing at -0.16% from 2003 to 2015, this is significant as oil spill affected water bodies are contaminated, thereby rendering it inhabitable and unusable, leading to significant decrease of clean water in the study area.

Mangrove and vegetation, is also decreasing significantly at the rate of -2.82% and -1.92% respectively from 2003 to 2015, this is by far the most significant decrease in the study area, as oil spill degrades farmland and plantain there by rendering it useless for economical purposes.

Settlements decreased at a rate of -1.16% from 2003 to 2015, oil polluted communities are forced to migrated to other unpolluted areas since oil spill pollutes the water, land and destructs daily activities. With no other way of farming and providing for themselves the inhabitants of these affected communities are forced to abandon their homes for a better environment

Degraded environment increased at a rate of 3.39% from 2003 to 2015. This signifies increased oil pollution from oil wells, oil pipelines and pipe vandalism in the study area.

The increasing trend of degraded environment in Gokana L.G.A should be monitored and clean up plans should be step up so as not to lose more landuse features in the foreseeable future.

Table.5.5: Trend of change & Annual rate of change of landcover/landuse of Gokana L.G.A from 2003 to 2015

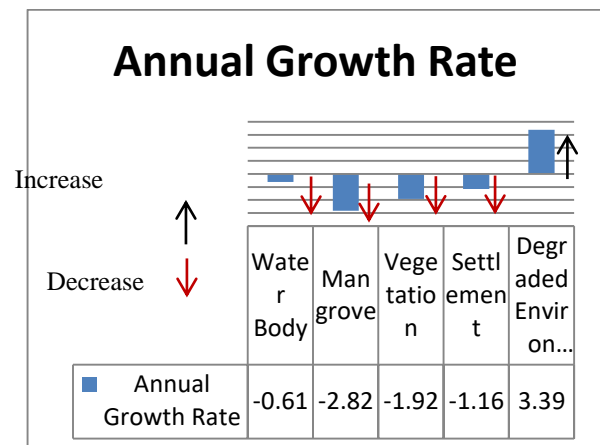| Class Type	Difference (Hectares)	Total Area (Hectares)	Trend of Change (%)	Annual Rate (%)
	2003-2015	2003-2015	2003-2015	2003-2015
Water Body	-300	4100	-7.32	-0.61
Mangrove	-2000	5912	-33.83	-2.82
Vegetation	-3040	13186	-23.05	-1.92
Settlement	-2300	16498	-13.94	-1.16
Degraded Environment	3100	7610	40.74	3.39

Fig.4.6: Annual growth rate of landcover/landuse of Gokana L.G.A between 2003and 2015

V. SUMMARY & CONCLUSION

This study indicated that the annual growth rate of water bodies is decreasing at -0.16% from 2003 to 2015, Mangrove and vegetation, are also decreasing significantly at the rate of -2.82% and -1.92% respectively from 2003 to 2015, this is by far the most significant decrease in the study area, as oil spill degrades farmland and plantain there by rendering it useless for economical purposes.

The study also indicated that settlements decreased at a rate of -1.16% from 2003 to 2015, oil polluted communities are forced to migrated to other unpolluted areas since oil spill pollutes the water, land and destructs daily activities. With no other way of farming and providing for themselves the inhabitants of these affected communities are forced to abandon their homes for a better environment.

Finally, the study indicated that degraded environment increased at a rate of 3.39% from 2003 to 2015. This signifies increased oil pollution from oil wells, oil pipelines and pipe vandalism in the study area from 2003 to 2015. This increasing trend of growth of degraded environment in Gokana L.G.A should be monitored and clean up plans should be step up so as not to lose more landuse features in the foreseeable future.

The oil spill management system aims to achieve a knowledge- based system which can choose the most suitable method of response in shorter time by analyzing the various sensitivity factors of coastal environment, affecting parameters on oil spill movement, environmental concerns in oil spill response, and consequent monitoring and clean-up measurements. The developed system would be able to provide a reasonable 'any- time' mechanism so that in most cases some reasonable response actions can be put forward. The system is useful in speeding of response actions especially in the regions which still suffer from the shortage of enough experts for responding the disasters.

The major advantage of this integration is the ability to extract oil spill parameters such as location, linear size and spill areas. Spatial and temporal information, i.e. oil spill distribution at the sea, its frequency and evolution in time allow the scientists to establish the major cause and source of oil spills, and then outline the risk areas. Within the GIS-approach, the tasks of analysis, modeling and forecasting of natural processes influencing the drift and spreading of oil spills can also be easily solved on the basis of standard GIS modules or linking it with other useful applications. This integration of technologies can qualitatively and quantitatively characterize not only the spatial and temporal distributions of oil spills, but also environmental conditions of the sea basins as a whole.

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