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Deforestation and Environmental Degradation in the Niger Delta – A Case Study of Bayelsa State Nigeria

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***Abstract*—** *Deforestation and environmental degradation have remained a major threat to the environment and livelihoods in the Niger Delta Region of Nigeria for several decades now. Remote Sensing (RS) Technology in combination with Geographic Information System (GIS) can render reliable information on land use dynamics. This study considered the extent and degree of deforestation and environmental degradation activities in Bayelsa State of Nigeria by RS and GIS combination technologies. The 2013 Landsat TM Satellite Remote Sensing data was used to identify and classify forest area in five Local Government Areas (Brass, Ekeremor, Nembe, Ogbia, and Southern Ijaw) of Bayelsa State covering a period of 26 years, from 1987 to 2013. These include Area calculation, overlay and image differencing. The result showed that built-up area which was 16.68 percent of the study area in 1987, increased to 34.96 percent of the study area in 2013. Vegetation cover which was 50 percent of the study area in 1987 decreased to 38.5 percent in 2013. Water body decreased from 33.32 percent of the study area in 1987 to 26.54 percent in 2013. The magnitude and rate of deforestation occasioned by development projects, agriculture, seismic operations, oil theft and artisanal refining, among others is substantial, unsustainable, and environmentally devastating and could be attributed to rising population and unsustainable consumption patterns that threaten forest and other natural resources in the State. The implications of this on climate change, flooding, and food security among other effects cannot be over-emphasized. Therefore, communities should be assisted by stakeholders to develop livelihoods that reduce dependence on forest while aggressive public enlightenment campaigns on the dangers of oil theft, artisanal refining of crude oil, deforestation and the need for forest preservation be carried out. Governments are all levels and other stakeholders are hereby enjoined to enforce relevant regulations on deforestation and environmentally degrading activities in the nation and Bayelsa State in order to check these unwholesome practices by the inhabitants.*

***Keywords*—** *Forest, deforestation, population growth, GIS, water body, Remote sensing, area, environment, communities, degradation.*

I. INTRODUCTION

Deforestation is defined by Intergovernmental Panel on Climate Change (IPCC) as the "permanent removal of forest cover and withdrawal of land from forest use, whether deliberately or circumstantially" [17]. Forest conversion to pasture, cropland, or other managed uses is considered the same as deforestation unless noted otherwise. United Nations Framework Convention on Climate Change (UNFCCC) and IPCC employ a minimum crown cover criterion of 10 to 30 percent to differentiate between forests and non-forests. If crown cover is reduced below this threshold, deforestation has occurred.

Deforestation is often driven by government-supported agricultural and timber policies, international markets for agricultural and forest products, population growth, and expansion of road networks. It is carried out by individuals/entities with sufficient capital to clear forests. Generally, it requires money to pay for the equipment and labor necessary to clear forests. Whereas deforestation eliminates the forest canopy, degradation encompasses all actions resulting in carbon emissions that do not involve elimination of the canopy. Degradation can result from selective logging, grazing within forests, and understory fires as well as overcutting for fuel wood and subsistence agriculture. Degradation causes the gradual thinning of forests and can lead to deforestation, as seen in studies from the Brazilian Amazon [2]. In the vicinity of roads and settlements, degradation may be at least as widespread as deforestation [13][2].

The potential carbon benefits of reducing forest degradation are enormous; however, degradation is more difficult to identify and monitor than deforestation because of the sophisticated remote sensing program and ground-truthing required. Also, carbon fluxes associated with forest degradation are more tentative. These challenges have created some concerns about the practicality of including degradation in a policy to abate forestry emissions

Drivers of Deforestation

For any reduced emissions from deforestation and degradation (REDD) policy or measure to succeed, the factors driving deforestation must be well articulated. These factors and their interactions vary among deforestation cases, and therefore make generalizations difficult. In fact, the factors that drive deforestation in most cases do not play a role in others. Understanding the case-specific factors influencing deforestation is as vital as securing the necessary funding to implement REDD activities. As seen in past projects in the forestry sector, investing in forest conservation projects without understanding the causes of deforestation can waste resources and fail to slow deforestation rates [3].

Two major reviews of existing studies on drivers of deforestation include the background document for the UNFCCC's Subsidiary Body for Scientific and Technological Advice workshop on the reduction of emissions from

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deforestation in developing countries [15], and a thorough meta-analysis by Geist and Lambin [4] that examines the proximate and underlying causes of tropical deforestation. A wide-ranging review of the major studies reveals that deforestation is driven by a number of direct and indirect factors that extend beyond the forestry sector. Only a few drivers are commonly universal. These drivers and other factors interact differently among regions and even among cases. In several cases, factors related to economic development and the expansion of agriculture interact with other factors to drive deforestation.

Geist and Lambin [5], in their analysis, present a useful insight for understanding how proximate factors and underlying drivers interact to cause deforestation. Proximate causes are anthropogenic activities that directly affect the environment at the local level. Underlying drivers are social, economic, political, and/or cultural processes that indirectly cause deforestation.

"Other factors" or predisposing conditions, such as soil quality and topography, also affect the possibility of deforestation.

Proximate Causes of Deforestation

Proximate causes are the direct, immediate causes of the removal of forest cover and are often determined by a combination of underlying drivers as discussed below.

Agriculture

In the tropics, fertile land can be scarce, and the forest frontier offers untapped agricultural potential. The forest frontier is populated by poor and displaced people [16], and increasing population pressure on the forest boundary - from urban unemployment, for example - increases the pressure for agricultural expansion and deforestation. Agricultural expansion is a major cause of tropical deforestation around the world and was a cause in 96 percent of the 152 cases of deforestation examined by Geist and Lambin [5][15]. Agricultural expansion includes establishing permanent crops, cattle ranching, shifting cultivation, and colonization and resettlement on the forest frontiers. Although shifting cultivation is often identified as a major cause of deforestation, Tomich *et al*. [12] found that permanent cropping and cattle ranching are equally influential. Cultivation of subsistence food crops dominates the forest clearing that is done for permanent agriculture [5].

Wood Extraction

Generally, logging alone does not lead directly to deforestation, yet when in concert with other factors it can cause forest conversion [16]. Selective logging of trees with high commercial value contributes to forest degradation. Degraded forests may ultimately become deforested land; in addition, degraded forests are more susceptible to fire than intact forests. Though the effect of selective logging is less than that of clear cutting, it nevertheless requires roads and infrastructure, which are highly associated with deforestation. One-time logging is also used to clear land for agriculture. In Africa, frontier forests are cleared through harvesting for fuel wood and poles [6].

Road Construction

Road construction provides access to forests and is associated to deforestation. The absence of roads is a barrier to entry to forests. Without roads, timber operations, commercial agricultural businesses, and individual settlers would not be able to access and exploit forest resources beyond the forest frontier. The construction of roads opens up the forest interiors to exploitative activities. Other infrastructure like dams, markets, schools, hospitals, and operations such as, pipe-laying, and seismic operations, are closely associated with deforestation.

Underlying Drivers of Deforestation

Underlying drivers of deforestation are the broader economic, political, technological, cultural, and demographic factors and the fundamental social processes that strengthen the proximate factors of deforestation. Often the underlying drivers act in gig with one another to enable the proximate causes.

Economic Factors

Worldwide and national economic factors play a major role in deforestation. Increased prices and expansion of agricultural markets increase deforestation pressure [6][3]. Commercialization of timber and other forest products also drives deforestation [4][16]. Increased gross domestic product (GDP) may have a positive or negative effect on deforestation [13][3]. Market structures and market variables can also have varying effects, depending on how they affect the profitability of forest uses. Poverty and lack of employment may encourage deforestation via forest clearing for subsistence agriculture.

Policy and Institutional Factors

Policy and institutional factors play a significant role in deforestation. In some cases, policies encourage deforestation through agricultural incentives, transportation and infrastructure development, urban expansion, and timber subsidies [6][13][16][3]. Weak governance institutions and corruption are associated with illegal logging in the Niger Delta region of Nigeria [11], and parts of Asia and with agricultural expansion in Latin America. Not only do weak institutions and corruption lead to deforestation, they also impede the development of local capacity to implement REDD measures and projects. Poorly defined property rights and land tenure matters and concerns can result in open access forests that are overexploited. However, establishing property rights may further encourage deforestation, depending on how property rights are assigned and how resources were historically used by the stakeholders. Chomitz [3] suggests that land tenure issues be addressed while a forest is still intact—before it becomes a frontier forest subject to competing interests.

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Technological Factors

Technological factors affecting deforestation include technologies to increase agricultural intensification and inferior technologies in the logging sector that lead to wasteful practices [4]. Technologies that increase the profitability of agriculture can promote the expansion of agriculture into forested land that is less suitable for agriculture and would otherwise have resulted in marginal agricultural returns [1][4]. Supposedly, technologies that encourage the intensification of agriculture can decrease deforestation pressure by increasing productivity and employment on a given plot [3].

However, there is little evidence indicating that this trend is taking place, and if technologies cause more in-migration to the forest frontier, such technologies may encourage further deforestation [12].

Cultural Factors

Geist and Lambin [4] found that cultural factors contribute to the economic and institutional drivers that support deforestation. Cultural factors include attitudes and lack of public concern for forest conservation, as well as the willingness to continue historical forest practices such as burning.

Demographic Factors

Natural population growth alone has a minimal impact on deforestation. However, in-migration and colonization of the forest frontier increase deforestation pressures [5][3]. The population of Bayelsa State has increased significantly in the present political dispensation due to migration from neighbouring States seeking better job opportunities that exist as a result of developmental activities in the State.

Other Factors

Among the other factors affecting deforestation, predisposing environmental conditions can affect whether a section of forest will be selected for deforestation. Areas that are easy to access, have suitable topography for agriculture, and have high soil quality are more vulnerable to deforestation pressure than others that are not.

Regional Differences

Although the causes of deforestation vary around the world, some regional trends result from similar social, economic, and environmental conditions within a region [15]. In Africa, population pressure drives agricultural expansion, which causes deforestation [7]. Land rights are also a factor in Africa, where uncertain land tenure drives a shift from communally owned land to privately held land and results in deforestation caused by shifting agriculture [5].

In Latin America, land-use policies tend to favor agricultural expansion by medium and large

Operations [7][5][15]. Cattle-ranching is a main factor contributing to deforestation [7][16][3].

In Asia, policies favoring logging and agriculture drive deforestation [5][15]. Logging operations are carried out by larger companies, whereas agricultural expansion is carried out by small farmers [16].

Interacting Factors

Deforestation cannot be pinned down to one simple cause; rather, it is caused by a combination of proximate and underlying factors. The dynamics of these interactions are often location specific, and lessons learned from one locale do not necessarily apply to others. Although this makes generalizations about deforestation difficult, Geist and Lambin [4] identified some trends in their analysis of 152 studies of deforestation. They found that deforestation was often associated with the interaction of three or four underlying drivers relating to two or three proximate causes: agriculture–wood–road proximate causes driven by economic, policy, institutional and cultural underlying drivers; agriculture–wood proximate causes driven by technological underlying drivers; and agriculture proximate causes driven by population expansion.

The agriculture–wood interaction was especially prevalent in Asian cases, and the agriculture – road interaction was especially prevalent in Latin American cases.

Despite those trends, each case exhibited unique inter-linkages. Furthermore, some factors were present in multiple cases but interacted differently according to local circumstances, making it difficult to distill an overarching theory of deforestation. In all, deforestation results from the complex interaction of a number of factors. These interactions are influenced by local conditions such that drivers of deforestation must be examined on a case-by-case basis to design an appropriate REDD program.

II. Study Area

The study area is five Local Government Areas of Bayelsa State namely: Brass, Ekeremor, Nembe, Ogbia, and Southern Ijaw.

Profile of Bayelsa State

Location

Bayelsa State is geographically located within latitude 04° 15' North, 05° 23' South and longitude 05° 22' West and 06° 45'East. It shares boundaries with Delta State on the North-West, Rivers State on the East and North-East, and Atlantic Ocean on the West and South [9].

Land /Vegetation

Bayelsa State is a tropical rainforest and mangrove swamp with an estimated area of about 21,110 square metres. More than three quarters of this area is covered by water, with a moderately low land stretching from Ekeremor to Nembe. The area lies almost entirely below sea level with a maze of meandering creeks and mangrove swamps [9].

In the north, it has a thick forest with arable lands for cultivation of different cash crops.

Agricultural Activities

The major agricultural activities of the people of Bayelsa State are fishing, farming (food and cash crops), palm wine tapping, timber and lumbering, local gin making, palm oil milling, among others.

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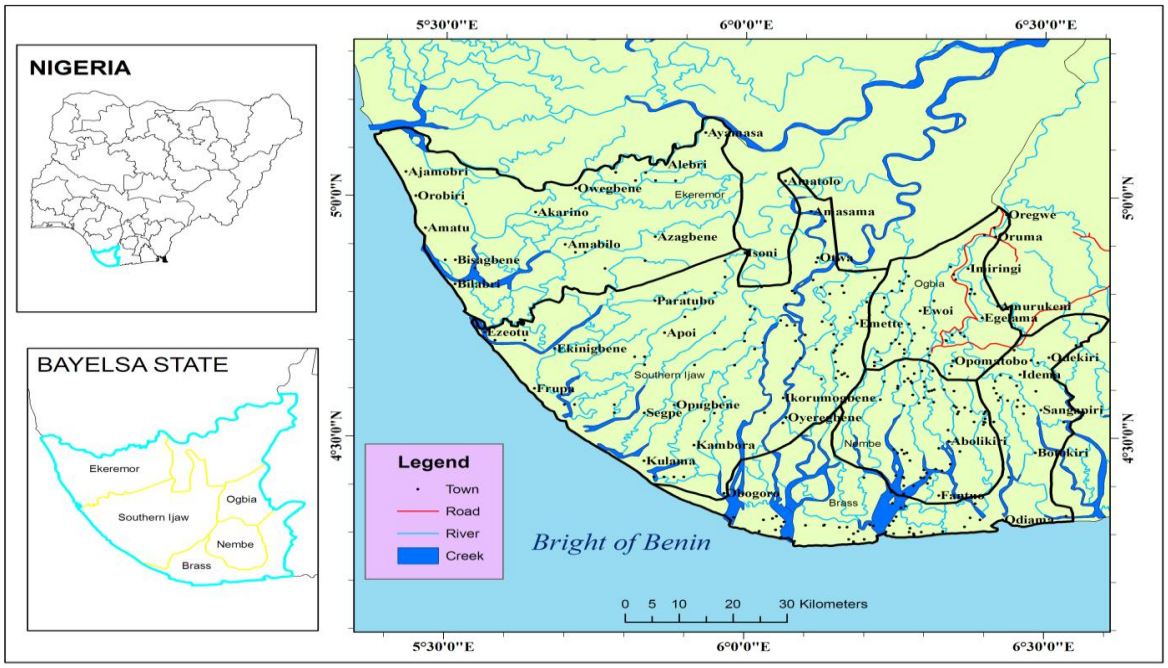

Fig. 1: Map of the Study Area

Economic Activities

Bayelsa State is a major oil and gas producing area and it contributes over 30 per cent of Nigeria's oil production. There are hundreds of oil wells and flow stations across the State. Oloibiri in Ogbia Local Government Area of the State is where oil was first struck in Nigeria in commercial quantity in 1956. The major oil exploration and production companies operating in the State are Shell Petroleum Development Company of Nigeria Limited (SPDC), Nigeria Agip Oil Company (NAOC) and ChevronTexaco. In addition to oil and gas, the State has large reserves of clay, sand and gravel of importance to the industrial sector. Also, trade, carving, and weaving are some of the economic activities in the State.

Politics and Administration

Bayelsa State was created on October 1, 1996 out of the old Rivers State and the name Bayelsa, is an acronym of three former Local Government Areas – Brass, Yenagoa and Sagbama in the then Rivers State. It now has a total of eight (8) Local Government Areas; 24 State Constituency seats in the House of Assembly; 8 Federal House of Representatives seats; and 3 Senatorial seats. The three Senatorial districts of the State are Bayelsa-East, Bayelsa-North and Bayelsa-West.

III. Materials and Methods

A 1987 Administrative map of Bayelsa State (scale 1:200,000) was acquired from the Rivers State Ministry of Lands and Survey. This map served as base map. Then from the Regional Centre for Training in Aerospace Survey (RECTAS, Ile Ife, Osun State; SPOT 5 Satellite imageries of 2013 with a resolution of 10m and Shuttle Radar Topography Mission (SRTM) data of 1987 with a resolution of 30m were acquired. The base map (which was in analogue form) was scanned and converted into raster image and imputed into ArcMap GIS version 9.3 environment, geo-referenced to a universal transverse Mercator (UTM) grid to allow compatibility and comparison with other data sets to enable the extraction of Bayelsa from the rest of Nigeria. Various data enhancement techniques such as linear enhancement and image enhancement operations were carried out for better visual interpretation, to reduce noise distortion in the image prior to a multi-band image classification and to detect line features in the satellite image to aid structural interpretation. Vegetation cover, water body and built-up were identified and characterized, the pattern of spread of zones was mapped using image classification; accuracy was assessed using overlay technique including Median filtering for smoothening homogeneous areas of the image, Contrast Manipulations to reduce cloud cover and haze over the image, Laplace Filter operator to sharpen the image Line and Edge enhancement operator to highlight all linear features.

IV. Results and Discussion

From Table 1 and Fig. 2 below, it would be seen that built-up area was 1,234.3km^2 representing16.68 percent of the study area in 1987. In 2013 built-up area has increased to 2,564.50km^2 representing 34.96 percent of the study area as shown in Fig.4. This could be attributed to the rapid urbanization in major towns since the creation of the State in 1996. The establishment of the Niger Delta University at Amassoma, Federal University at Otuoke, Liquefied Natural Gas (LNG) Plant at Brass, Gas Gathering and Turbine Plant at Gbaran amongst other development projects in different sectors have accounted for significant deforestation in Bayelsa State which is consistent with the result of this study – that is

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an increase in built-up area from 16.68 percent in 1987 to 34.96 in 2013.

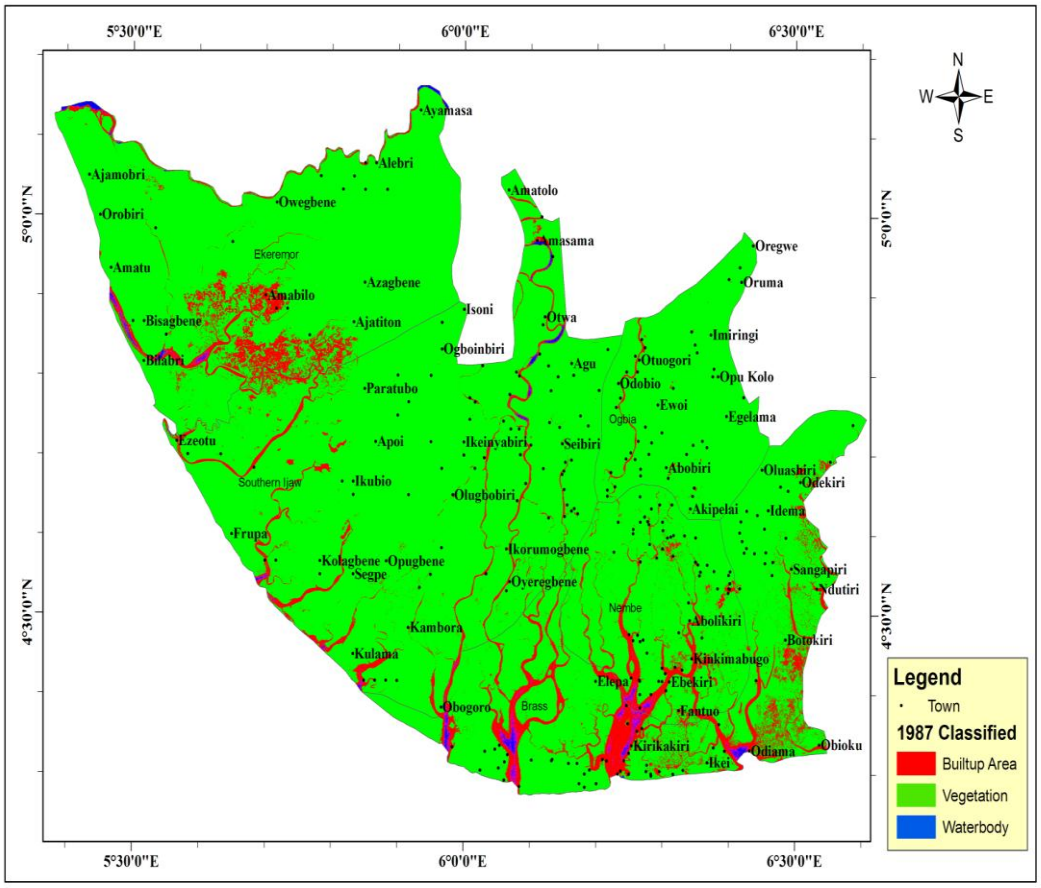

Fig. 2: 1987 Classification Map (Satellite Image) of Study Area

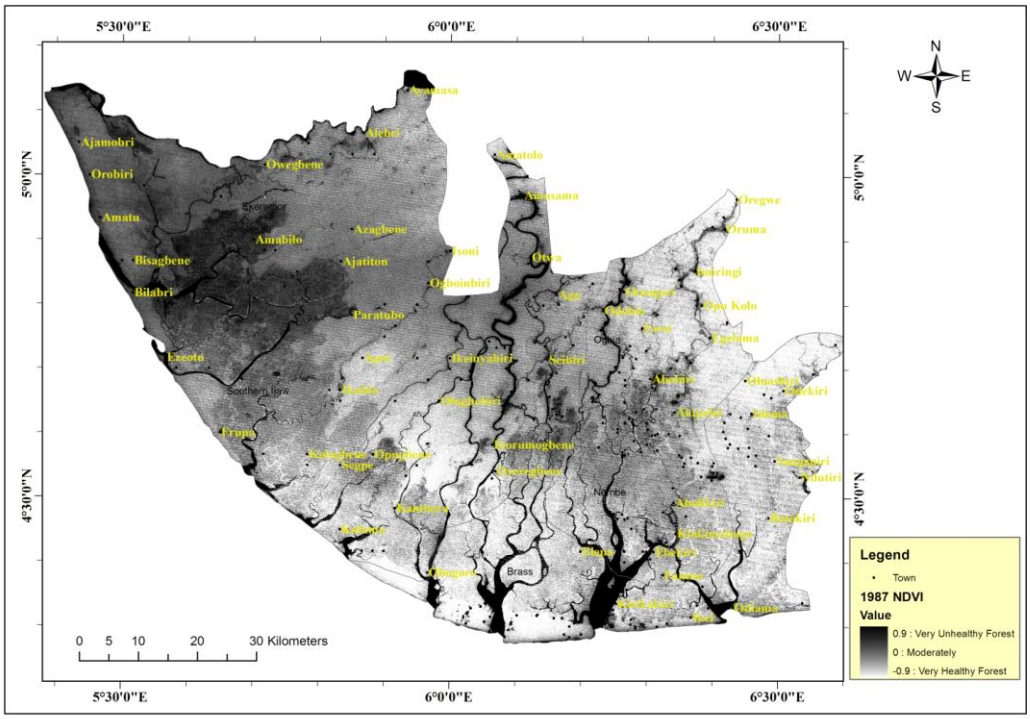

Fig. 3: 1987 NDVI Map (Satellite Image) of Study Area

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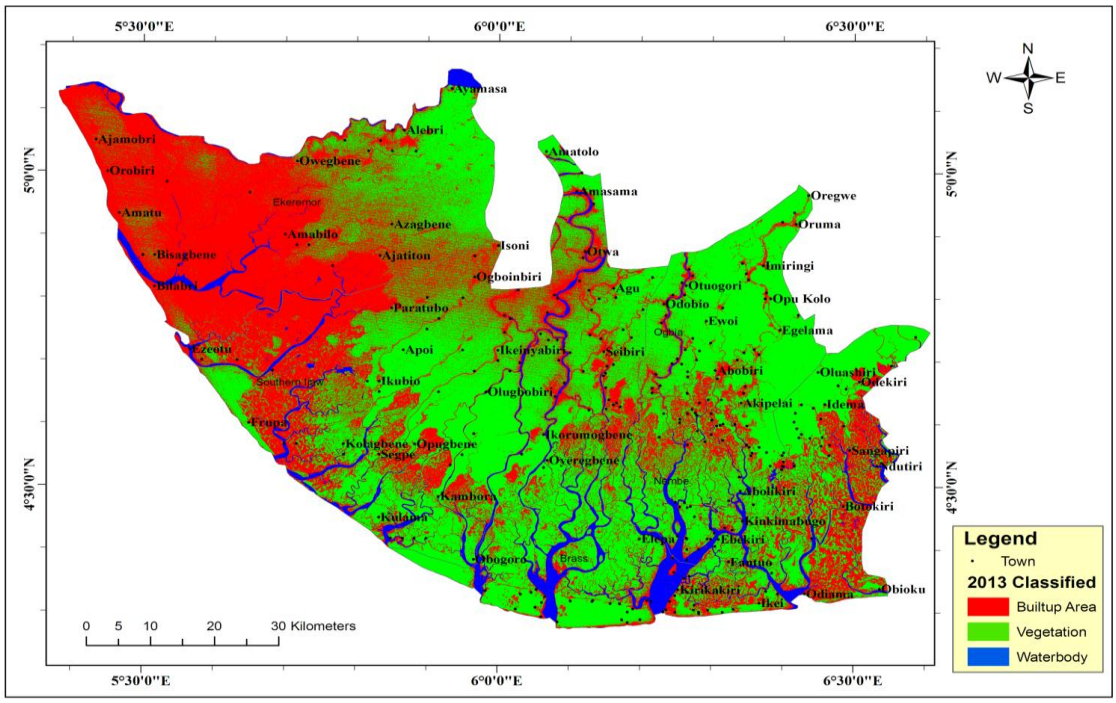

Fig. 4: 2013 Classification Map (Satellite Image) of Study Area.

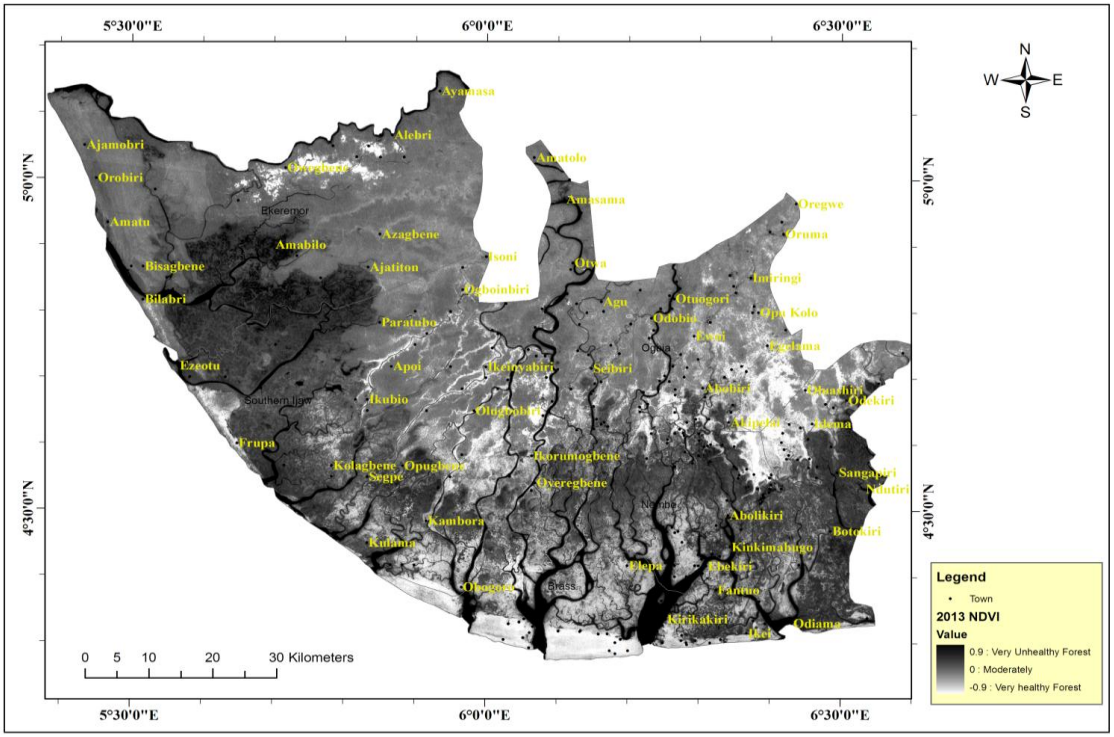

Fig. 5: 2013 NDVI Map (Satellite Image) of the Study Area

Table 1: Magnitude and Percentage of Change of Land Use / Land Cover in the Study Area

	Year 1987		Year 2013	
Classes	**Area Km²**	**Percentage (%)**	**Area Km²**	**Percentage (%)**
Built-up Area	1,234.3	16.68	2,564.50	34.96
Vegetation	3,668.45	50	2,824.17	38.5
Water body	2,434.15	33.32	1,945.3	26.54
Total	**7,336.9**	**100**	**7,333.97**	**100**

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Vegetation from Table 1 above was 3,668.45km^2 representing 50 percent of the study area in 1987 and decreased to 2,824.17km^2 representing 38.5 percent of the study area in 2013 as seen in Fig.4. This could be partly explained by the rate of industrialization and urbanization in the State as mentioned earlier. Also, the aggressive logging of trees due to high demand on wood and timber products equally account for the reduction of vegetation and deforestation in Bayelsa State. Agricultural mechanization and expansion projects by the governments as well as intensive farming methods coupled with the sourcing of firewood and wood fuel by the local communities at forest frontiers have also resulted in deforestation and vegetation reduction.

Worthy of mention here as a factor responsible for vegetation reduction, deforestation and forest degradation in Bayelsa State is the high rate of oil spills, oil thefts and artisanal refining taking place in the Niger Delta region. According to UNEP [14], in Bodo West of Gokana Local Government Area of Rivers State, an increase in artisanal refining between 2007 and 2011 has been accompanied by a 10 percent loss of healthy mangrove cover, or 307,381m^2. If left unchecked, this may lead to irreversible loss of mangrove habitat in this area. It was further observed that mangrove trees cleared or cut during seismic operations take between 25 to 30 years to regenerate.

From Table 1 above, water body was 2,434.15km^2 representing 33.32 percent of the study area in 1987, and decreased to 1,945.3km^2 representing 26.54 percent of the study area in 2013. This can be attributed to the persistent dredging and sand-filling activities which are prerequisite for citing projects in the State. Governments, corporate bodies, private developers and communities are all engaged in land reclamation efforts for housing, amenities, recreation, remediation, and planning purposes, thus reducing the area hitherto occupied by water. This result of reduction in water body is also consistent with similar studies done in Rivers State.

V. Findings

Based on this study, the following findings were made:

(i) Built-up area increased from 16.68 percent in 1987 to 34.96 percent in 2013.
(ii) Vegetation cover decreased from 50 percent in 1987 to 38.5 percent in 2013.
(iii) Water body decreased from 33.32 percent in 1987 to 26.54 percent in 2013.

VI. Recommendations and Conclusion

Based on the findings of this study, it is recommended that the Government of Bayelsa State should strengthen its institutions and agencies saddled with responsibilities of guarding and protecting against the indiscriminate logging of wood for commercial purposes considering it adverse effects on the environment.

Concrete steps and adequate monitoring of pipelines, oil facilities and installations to check the increasing rates of oil theft and artisanal refining that have impacted negatively and degraded the environment.

Aggressive tree planting project and forest conservation program should be embarked upon in partnership with most multinational oil companies like Shell Petroleum Development Company of Nigeria Limited (SPDC) that has similar pilot projects in Taylor Creek Forest Reserve in Bayelsa State, Gele-Gele and Urhonigbe Forest Reserves in Edo State, Stubbs Creek Forest Reserve in Akwa Ibom State, and Andoni Forest Reserve in Rivers State to counteract the adverse effects of deforestation and forest degradation in Bayelsa State and the Niger Delta region.

In support of the SPDC-sponsored biodiversity plan and effort, the Edo State Government passed a biodiversity law in 2007. The law amended the logging concession process and transferred forest management to community based management and grass-root consultative committees established by the biodiversity action plans.

The success of the plans depends on local communities taking ownership and responsibility for them. In 2007 SPDC worked with all 33 stakeholder communities in the reserves to establish community-based forest management institutions. Between 2008 and 2009, these communities replanted more than 100 hectares of degraded Urhonigbe forest reserve with 83,000 seedlings of timber species including mahogany and teak [11].

According to SPDC [11], one of the solutions identified to the problem of deforestation and environmental degradation is to assist stakeholder communities develop livelihoods that reduce their dependence on the forest. Therefore, governments at all tiers, oil multinationals and Non-governmental organizations should evolve measures aimed at assisting local communities in raising alternative sources of livelihoods not dependent on forest and forest resources.

Property developers in the State should be should be enlightened on the likelihood of floods in the State especially in low-lying areas and flood plains considering vegetation cover reduction and its environmental consequences.

Further work is required to convince members of the communities of the importance of preserving the forests, as enforcement of the biodiversity law and other relevant regulations is weak and has negatively affected the progress made in forest conservation plans. To this end, mass campaign and enlightenment on the importance of forest preservation and conservation should be embarked upon by governments at all levels.

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