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GEOSPATIAL INFORMATION ON LAND USE/LAND COVER OF THE COASTLINE ENVIRONMENT IN AKWA IBOM STATE BETWEEN 1986 AND 2018

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ABSTRACT

Akwa Ibom State is one of the States of the Niger Delta Region, Nigeria. The dynamic nature of the Niger Delta region makes it one of the most prominentecosystems in the world. This region has experienced dramatic environmental changes over time from both human-induced and natural processes. Assessing and monitoring the coastal and marine changes makes provision for information relevant to managing and planning the natural environments and human infrastructures in an area.Most studies on coastal and marine change in Akwa Ibom State and the Niger Delta Regionhave focused on classes and features such as erosion and accretion. However,considering the magnitude of environmental change in this region based on the increased human and climatic activities, adequate efforts are required in planning and proffering solutions for sustainable development.This study aims at assessing the land use/land cover of the coastal and marine environmentsof the Niger Delta Region of Nigeria, with a view to generate information on changes experienced between 1986 to 2018 using three (3) time periods; 1986, 2003 and 2018 for the purpose of sustainability development and adaptively managing future occurrence and damages. Landsat TM of 1986, Enhance Thematic Mapper plus (ETM+) of 2003, and the Operational Land Imager (OLI) of 2018 data were used for this study. Result from this study showed thatthere was significant reduction in the area coverage of the Bare land over time, while there was progressive increase in the area coverage of the Built Up, Farmland, and Water Body. The progressive increase in the area coverage of Built Up, Farmland and Water Body may be attributed to both anthropogenicfactors, including Government policies, developmental activities, urbanization, and natural factors such as climate change, flooding and gully erosion. The scenario was different with regards to Forested Area, as increase was observed between 1986 and 2003 and decrease between 2003 and 2018, which may be attributed to inconsistent environmental policies as well as human actions with regards to environmental protection. A comprehensive environmental protection approach is recommended to ensure sustainable livelihoods and development in the area. A combination of geospatial technique and conventional empirical analysis could enhance further elucidation of the causes and pattern of environmental changes, for informed decision-making and sustainable development in the area.

Keywords: *Land use/Land cover classification, Satellite imageries, Remote Sensing, Geographic Information System, and Coastal Environment.*

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1. Introduction

The coastal environment is a highly endowed region with natural resources that promote the livelihood of humans, plants and animals. It is a dynamic environment with many physical processes that responds to coastal hazards and anthropogenic events associated with environmental degradation such as flooding, sea level rise, land subsidence, and erosion/sedimentation(Oyegun, Lawal, & Ogoro, 2016). In the last few decades, the Niger Delta region has been faced with dramatic increase in its population and economic activities resulting to enormous benefits and processes not just to the region alone but to the adjacent states and the entire country. These benefits and processes have also created environmental changes to the oceans and the coastline in this region. (Georgia Tech, 2018; Ekong, 2017).

According to the United Nations (UN), over three (3) billion people depend on resources from the marine and the coastline for livelihood and other human necessities. These resources also serve to regulate global climate and act as a sink for greenhouse gases and habitat for biodiversity (UN-DESA, 2015; Ijiomah, 2018). However, due to the prevalent human activities and impacts globally, Coastal and Marine Socio-Ecological Systems (CMSES) have been seriously degraded from pollution, erosion, flooding, habitat destruction, exploitation, climate change etc. (Nahuelhaul *et al*., 2016), thus making the coastal and marine environments more vulnerable to natural hazards and thereby increasing the risk and resultant impact (Lozoya*et al.*, 2014). The processes and effects are very much the case in Nigeria with the rapid economic expansion in the Niger Delta.

In Akwa Ibom State, noticeable changes and impact of activities and processes on the region have been basically the loss of mangrove trees, erosion, oil spills and exploitation. The mangrove that once provided for fuel and habitat is unable to oppose the pressure and toxicity levels of petroleum chemicals(Lugo *et al.*, 2014; Chukwuebuka *et al.*, 2020). Oil spills and other exploitation activities have caused contamination to marine life and consumption of these sea foods has posed a high level of risks to human health (US DOE, 2003). In addition, as the region embarks upon unprecedented phase of economic expansion in the 21st century, pressure from environmental human development such as housing development, road construction for transportation, economic development and demographic changes has also grossly contributed to the resulting changes mentioned above (Yaw & Edmund, 2006).

The rapidly increased changes and impacts in this region have spurred an increased desire for researchin order to determine precautionary and adaptive measures, especially sincethe impact is worsening and the speed of change is not easily known. In an attempt to monitor and proffer solutions to the rapid impacts caused by these changes, several methods have been employed to study and monitor coastal and marine environments, including traditional methods. A lot of the works published are limitedto local observations and basic surveying and mapping techniques (Adegoke, *et al*., 2010), but not much works is carried out on the impact of change between different time range. A good number of researches have stressed the importance of remote sensing (RS) in monitoring the coastal and marine region and the need to apply Geographical Information System (GIS) to identify relevant features that are predictive for change in the region.

Adegoke, *et al*., (2010), carriedout time series analysis of recent changes in the Niger Delta Coastline using Satellite Imagery in order to fill up the loopholes. Data used for this included Landsat TM images of 1986 and Landsat ETM+ of 2003 both covering the Niger Delta area of Nigeria. Erdas Imagine Version 8.7 and Arc Info 9.1 software were used for the GIS

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operations. Results of the analysis showed that among other things, erosion was dominant. Also a total area of 46.535sq.km along the coastlines with27.65sq.km (59.43%) constituting of eroded area, and 18.88sq.km (40.57%) area showing coastal sediment accretion was observed.

In another study, (Ekong, 2017), made anattempt to detect shoreline and land use change with a view to determining the trend and nature of the change in Ibeno, Akwa Ibom State, Nigeria. In this study, Landsat, Ikonos imageries and GIS techniques were utilized in capturing these changes over a period of 22 years precisely between 1986 and 2008 using 3 time periods. The study focused primarily on two factors; erosion and accretion of the study areas and the result of the analysis demonstrated an increase in eroded areas than accretion of the shoreline in the study area. A recommendation to monitor the shoreline change from time to time, establish and enforce developmental setbacks, implement development control measures as well as the introduction of integrated coastal zone planning and management within the Niger Delta region to reduce hazards and protect the beautiful sand beaches was suggested at the end of the study.

An analysis in the changes that had taken place in the coastline areas of the Niger delta region was carried out by (Chituru & Tamunoene, 2014) using remote sensing and GIS technology. The objective of this study was to explore the applicability of satellite imagery in monitoring of the coastline change and to deal with assessment of the vulnerability of the environment to physical processes around the coastline of the Niger Delta. In order to understand the reasons for the changes, Optical satellite imagery between 1972 and 2008 were utilized for analysis in addition to SRTM digital elevation model over the Niger Delta. The result of their study over 30 yearsdocumented that the Niger Delta coastline wasn't entirely eroding or accreting over the study period even after having periods of erosion and accretion in between. A major challenge with this study was an unavailability of data to quantitatively determine potential capital loss due to the effect of a highly vulnerable and unchecked erosive coastline.

Theuse of satellite RS and GIS techniques for monitoring, identification, mapping and analyses of coastal and marine environment have gained prominence in recent years as high resolution satellite data have become more readily available. However, researches employing these technologies to measure extent and impact of changes over time across different classes and features have been minimal. This study aims at assessing and generating information for the changes in the coastal and marine environmentsusing latest advances in geospatial information systems and remote sensing to implement comprehensive strategic action plans for adaptively managing likely unknown future conditions/occurrences.

2. Study Area

Akwa Ibom State is located in the coastal and southern part of Nigeria and covers a total area of 8,412km². It has a total population of about 5 million people and it is the highest oil and gas producing state in the country. The state is bothered in the south by the Atlantic Ocean. With the ocean front which spans a distance of 129km from Ikot Abasi in the west to Oron in the east. Akwa Ibom rates a major coastal zone in Nigeria with mangrove forest and sandy beach. Ikpa River Basin (the study area) covers about seven local government areas of the state. It is a tributary of the cross river basin in south eastern part of Nigeria and covers an area of 413. 5km². It is bounded by latitudes 4020N and 5012N and 7031E and 8011E.

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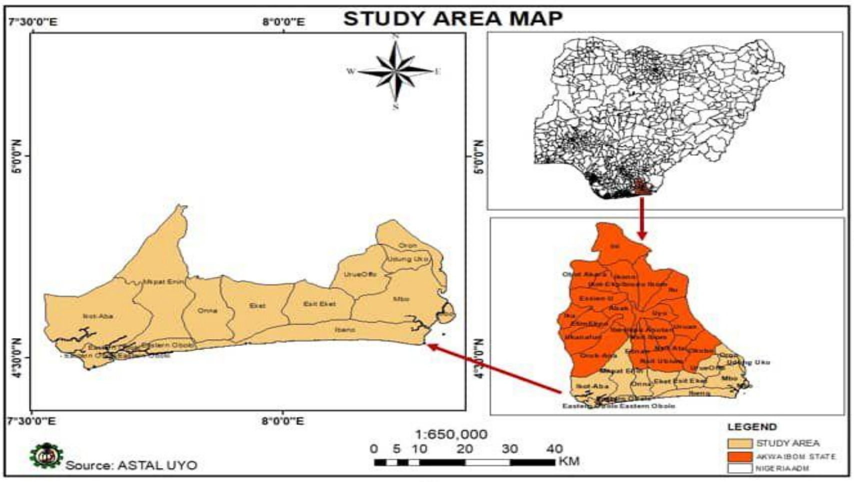

Figure 1: Map showing study ar**e**a

3. Methods

To achieve the objectives of the study, the methodology employed involved mainly satellite image processing and GIS analysis. Considering the terrain of the study area,three (3) sets of spatial data were used for the study,Landsat TM of 1986, Enhance Thematic Mapper plus (ETM+) of 2003, and the Operational Land Imager (OLI) 0f 2018 data were used for this study. Ground truthing data and GPS points of the coastal and marine environment visited. Image preprocessing, Image classification, image differencing, post classification combination overlaying, image fusion/ mosaicing, and image interpretation were applied.

a. Data Identification and Collection

The study began with variables/classes identification needed to assess environmental change at regional level. The classes consist of environmental information, including forested areas, vegetation, water bodies and bare lands(See Tables 1). Data matrices were designed for the variables covering the various periods between 1986, 2003 and 2018. The LANDSAT data were downloaded from USGS Earth Explorer. The Landsat TM image was downloaded for 19th Dec, 1986; Enhanced Thematic Mapper plus (ETM+) image for 8TH Jan, 2003 and the Operational Land Imager (OLI) for 31st January, 2018. The spatial resolution of the Landsat satellite data is 30m, and the TM and ETM+ images has a spectral range of 0.45-2.35 micrometer (μm) with bands 1 to 7 and 8 respectively, while the Operational Land Imager (OLI) extends to band 12. They were used for the image classification for more accuracy in the classification, a high resolution image of the Google earth for different years of the investigation 1986, 2003 and 2018 were equally used.

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Table 1: Identified Classes for Land use/ Land cover

Categories	Classes/Variables	Class Labels/Description
Environmental	Water Bodies	Areas covered with water, such as river, lake/dam, ocean, etc.
	Farmlands	Scrub Lands, Grasslands
	Vegetation	All forested area
	Bare Lands	All open grounds that are neither vegetated nor built-up, untarred roads, eroded area farm land or abandoned farmland and footpaths

The following methodology was applied to the three epochs of satellite image data in order to perform the study:

i. Data Pre-processing; Radiometric correction, Geometric correction, geo-rectification
ii. Image Processing; Spectral enhancement, colour composite generation, Digital Elevation Model (DEM) extraction.
iii. Image Classification; Differentiation of land cover and water types
iv. Post Classification; Image fusion, Image differencing, change detection and statistical analysis
v. GIS Analysis; Vectorization, Change mapping, and quantification

b. Geo-spatial Data Pre-processing

All the acquired data were pre-processed as it can be used to support a wide range of applications in such areas as global change research, agriculture, forestry, mining, land cover and change detection. The images can be used to map anthropogenic and natural changes on the Earth over periods of several months to two decades. The types of changes that can be identified include agricultural development, deforestation, desertification, natural disasters, mineral exploration and classification, urbanization, and the development and degradation of water resources. Etc. The Landsat Enhanced Thematic Mapper Plus (ETM+) and Landsat Operational Land Imager (OLI), Data extracted are composed of eight (8) and twelve (12) spectral bands respectively with wavelength ranging from 0.45 – 12.5 micrometers.

The Landsat ETM+ launched on the 15th April 1999 with spatial resolution of 30m and temporal resolution of 16 days has its 1st seven bands (band 1 – band 7) as observation bands which fall between the visible and infrared parts of the electromagnetic spectrum, with Bands 1, 2 and 3 having spatial resolution of 30 meters and a spectral range of 0.45 - 0.69 micrometers under the visible part of the electromagnetic spectrum and the other 4 bands (Bands 4, 5, 6, & 7) with spectral range of 0.77 – 2.35 micrometers under the infrared part of the electromagnetic spectrum. The types of changes that can be identified using the Landsat ETM+ and OLI include agricultural development, deforestation, desertification, natural disasters, mineral exploration and classification, urbanization, and land degradation.

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c. Image Classification

The LANDSAT data were captured under clear conditions (0% cloud coverage for all the images except for 1986 image which was affected slightly by cloud cover), hence atmospheric correction was carried out. All the images were pre-processed to rectify any geometric or radiometric distortions of the image. This correction process employs both Digital Elevation Models and Ground Control Points to achieve a product that is free from distortions related to the Earth, satellite, and sensor. The USGS also geometrically corrected and geo referenced both images to the WGS1984 datum and Universal Transverse Mercator (UTM) zone 32N coordinate system.The images were then clipped to the coastal and marine boundary at different year delineated from the Satellite image.

A supervised classification scheme with the Interactive Selection algorithm was used for the classification. The supervised classification was performed by creating a training sample, and based on spectral signature curve, various land-use classes were created namely: Water body, Bare land, Built up, Farmland and forested area. These classes were observed distinctively on the clipped image and were used for the classification.

i. Land Cover Change Analysis

In assessing the change over time, a supervised classification was carried out on the 1986, 2003 and 2018 Landsat images using Google earth high resolution images for the different years after proper coordinate transformation to ensure uniformity in projection to obtain a more accurate classification. The classified layer was further vectorized for further analysis such as calculation of geometry etc.To determine the land cover change within the 1986 to 2018, the areas of the classes for the different years were computed and compared. tables and pie chart were used to further explain the extent of change over the study period.

4. Results

The results of the study are presented and discussed below:

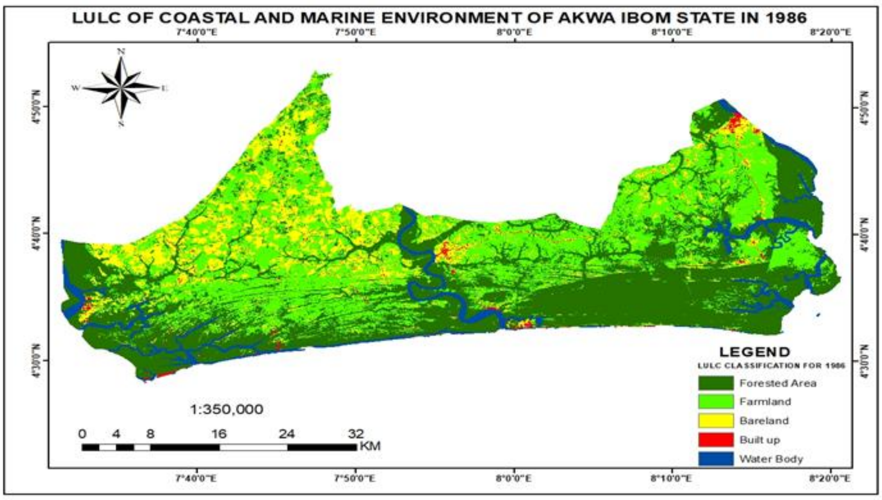

Figure 4.1: Map showing the LULC classes of the coastal and marine environment of Akwa Ibom State in 1986

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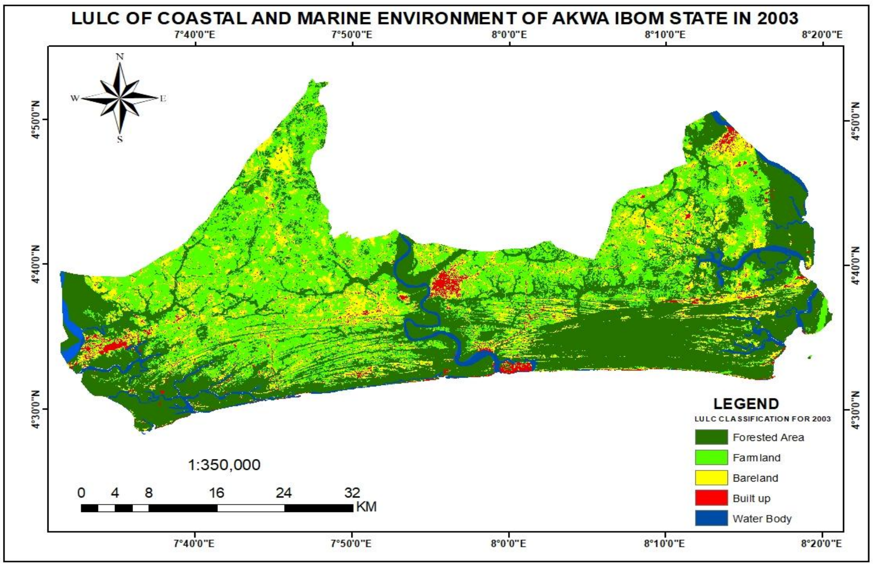

Figure 4.2: Map showing the LULC classes of the coastal and marine environment of Akwa Ibom State in 2003

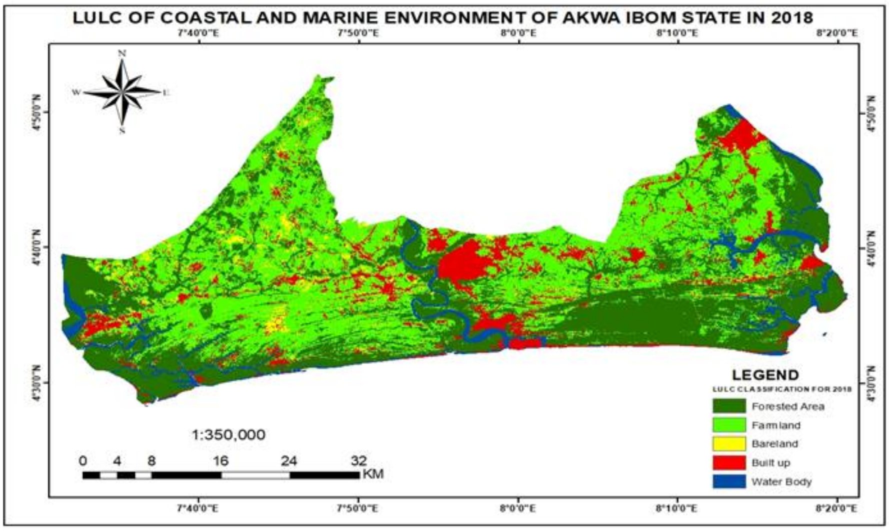

Figure 4.3: Map showing the LULC classes of the coastal and marine environment of Akwa Ibom State in 2018

a. Results of Land Use Land cover(LULC) Distribution and Change Detection analysis

This was carried out in order to investigate both the change, nature and magnitude of the land transformation due to human activities, climatic changes and natural causes. This analysis was carried out using Landsat, 5, 7 and 8 for the years 1986, 2003 and 2018 respectively. Bare land, Built Up, Farmland, Forested Areas and Water bodies were chosen as (Feature class name) for the supervised classification.

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Table 4.1: Table showing LULC Statistics over the entire study period.

Feature Classes	1986 LULC (km^2)	2003 LULC (km^2)	2018 LULC (km^2)
Bare land	377.83	303.84	55.98
Farm Land	676.47	686.41	788.19
Forested Area	853.09	873.59	835.46
Water Body	35.38	38.92	58.92

Table 4.2: Table showing LULC percentage coverage of the selected classes.

Feature Classes	1986 In (%)	2003 In (%)	2018 In (%)
Bareland	19.236	15.461	2.848
Farm Land	34.441	34.928	40.107
Forested Area	43.441	44.453	42.513
Water Body	1.801	1.98	2.998

Table 4.3: Table showing Change Rate between the Entire Study Periods (Km2)

Classes	Rate Of Change Between 1986-2003	Rate Of Change Between 2003-2018	Rate Of Change Between 1986-2018
Bare land	-73.99	-247.89	-321.85
Built Up	41.08	164.2	205.28
Farm Land	9.94	101.78	111.72
Forested Area	20.50	-38.13	-17.63
Water body	3.54	20.00	23.54

Table 4.4: Change Rate between the Entire Study Periods in (%)

Classes	Rate Of Change Between 1986-2003	Rate Of Change Between 2003-2018	Rate Of Change Between 1986-2018
Bare land	-3.77	-12.61	-16.38
Built Up	2.08	8.35	10.44
Farm Land	0.48	5.17	5.66
Forested Area	1.01	-1.94	-0.92
Water body	0.17	1.01	1.19

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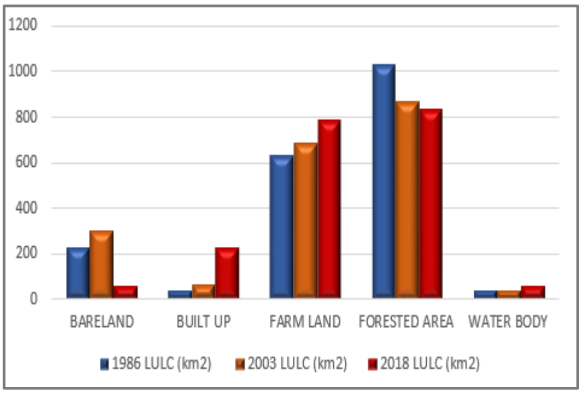
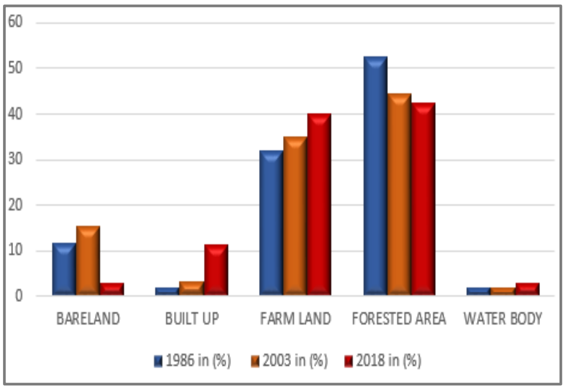
From table 4.4, it has been observed from the result that between the period of 1986 to 2003, the bare land experienced a deduction by 3.77, built-upincreased by 2.08, farm land increased by 0.48, forested area by 1.01, and water body by 0.17. The results also showed that within the period 2003 to 2018, bare land witnessed further deduction by 12.61, built up witnessed an increment by 8.35, farm land witnessed an increment by 5.17, forested area witnessed a deduction by 1.94 and water body witnessed an increment by 1.01 percentages. Finally, the table summarized the rate of change between a period of 1986 to the period of 2018, which showed a deduction by -16.38 for bare land, an increment of 10.44 for built up, an increment of 5.66 for farmland, a deduction of -0.92 for the forested area and finally an increment of 1.19 for water body.

From table 4.4, it was observed that the forested area and bare land throughout the study period have witnessed deductions thus showing that the mangrove and other forest components have been under serious attack as a result of anthropogenic and natural effect. The bare land has also experienced dramatic deductions over time, due to continuous agricultural activities, development and urbanization. However, Water body, farmland and built up have witnessed an increment over the years. The increase in the water body may be induced by climate actions and annual double-maxima rainfall which results in gully erosion, flooding, channels expansion, and other impacts in the area.





The result shows the pattern or nature of land cover changes with respect to the area. Figure 4.4 shows increase in the area coverage of Bare land between 1986 and 2003, and significant reduction between 2003 and 2018. It indicates that within the period (1986-2018), there was progressive increase in the area coverage of the Built Up, Farmland, and Water Body. The systematic and progressive increase in the area coverage of Built Up, Farmland and Water Body may be attributed to both anthropogenic and natural factors. Government policies, developmental activities, and urbanization are possible factors that could lead to increase in Built Up, while Farmland may increase due to increased farming activities and Government policies on Agriculture. The scenario was different with regards to Forested Area, as decrease was observed between 1986 and 2018. This may be attributed to human influence on the natural environment through deforestation and bush burning. Deforestation may occur due to man's quest for firewood, timber for construction, forest clearing for construction and other developmental purposes, among others. Government's negligence in enforcing environmental laws may also lead to depletion of the Forested Area.

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5. Conclusion and Recommendation

a. Conclusion

It is important to understand the effects of human activities, natural effects changes in regional climate of the study area. The findings of this study have revealed that there are more eroding than accreting portions for all the periods across the entire shoreline. This is as a result of human activities such as harvesting of mangroves, laying of pipelines carried out at the river estuary along the shoreline and developmental infrastructure. it was observed from the result that the mangroves have been witnessing a deduction throughout the entire study period so as bare land. Built up has increased tremendously all through the entire study period. The following physical planning measures could be put in place to minimize the impact of human activities.

b. Planting and Replanting of Mangrove Seedlings

Mangroves provide shelter to lots of habitat and is therefore recommended that re-vegetation of areas destroyed by nipa palm invasion is urgently needed by using women groups who depend on the exploitation of natural resources like fish, periwinkle, prawn, oyster, etc. and Community Based Organisations (CBOs) to start pilot mangrove seedling planting programme. The fast growing red mangrove species (Rhizophora racemosa) is recommended.

c. Monitoring of the Shoreline Change

To monitor the shoreline, change effectively, Hyperspectral sensors are needed to be able to monitor the rate of change along the shoreline in order to detect eroding areas and clear picture of the change over time. Satellite imageries should be acquired periodically along the Nigerian coast; However, Ikonos satellite imagery or imageries with high resolution (e.g. 1 m and below) have the potential for shoreline mapping and erosion monitoringand processing more quickly, with comparable precision, while offering a very high level of details. Also, the High Water Line (HWL) is always easy to extract from these imageries.

d. Establishment and Enforcement of Standards

There should be standards e.g. building line/setbacks to ensure that infrastructures, structures whether temporary or permanent are not sited too close to the shoreline so that they are not affected. Hence, development control measures should be strictly implemented to ensure that buildings and other structures are built in the appropriate zones and development plans should be approved by the planning authorities. Due to the dynamic nature of coastal shorelines, development in the area should be carried out within the context of Integrated Coastal Planning and Management (ICPM) policy involving land-use zoning for community infrastructures, structures, agriculture, industry, among others.

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