Wetland Inventory and Mapping for Ikorodu Local Government Area, Lagos

Orji, Godswill and Pepple, Godwill Tamunobiekiri, Nigeria

Keywords: Coastal Zone, Management, Remote Sensing

SUMMARY

Wetland conversion globally have resulted issues i.e. sea level rise, subsidence, imbalanced ecosystem etc. (Godstime et al, 2005; Pepple, 2011). The analyses of such conversion could be thematically extracted for spatial and temporal representation of urban encroachment into Ikorodu wetlands using the geo-information technology. The quest for the variation over years can be best represented in layers adopting the tri-stimulus colour theory (Lui and Mason, 2009). Landsat datasets were used for change detection during the three (3) epochs using the supervised minimum distance image classification approach. The rate and trend of urbanization and wetland change over a period of 21 years (1990, 2000 & 2011). The study accounts for conversion wetland into other established that urbanization in Ikorodu Local Government Area, (Lagos, Nigeria) results from influx from the rural areas which had resulted in the quest for more spaces to provide accommodation or employment for the teaming population, which was evident in the growth of the built up area from 3.12 sq.km - 182.25 sq.km in year 1990 and 2011 representing a rapid growth of 5741.35 with an annual change rate of 1205.68 (Orji, 2014). This study focuses on the challenges faced by geo-informaticians to evaluate wetland loss and the benefits of wetland conservation. The study therefore recommends that human induced activities (both individuals and government) should be reduced while efforts should be amplified on those activities that encourage wetland conservation and preservation rather than the immediate benefits derived from wetland conversion (Orji, 2014).

1.1 BACKGROUND OF THE STUDY

As part of natural ecosystem, wetlands where they occur in the landscape are valued for their contribution to ecological balance and biodiversity (Obiefuna *et al.*, 2012). Also, they are valued for the numerous goods and functions delivered freely to the ecosystem and human habitats which include flood storage and distribution, retention of sediments and nutrients, aquifer recharge, water quality improvement, aesthetic and educational benefits among others (Kindscher *et al.*, 1998). Unrestrained degradation of wetlands and ecosystem will inevitably lead to a loss or diminution of some or all of these functions. They also include human-made wetlands such as waste-water treatment ponds and reservoirs (RCS, 2007a). Urban populations and wetlands are said to have been engaged in a turbulent, somewhat symbiotic marriage since the dawn of civilization. Being essential for human well-being, wetlands have been progressively lost and degraded from human activities since then.

The rate of their loss is known to be greater than for any other type of ecosystem. Turner (1988), wetland ecosystems account for about six per cent of the global land area and are considered by many authorities to be among the most threatened of all environmental resources. Both the physical extent of wetlands and their quality (in terms of species diversity, etc.) have declined greatly over the past years (Turner, 1988). Most of the physical losses have been due to the conversion of wetlands to other land uses, for example residential and agricultural. The negative impacts of uncontrolled resource utilization on destabilizing ecosystem and the changing land use patterns makes communities vulnerable to lots of environmental and economical problems, and creating burdens on ecological resources of the world.

Development and preservation of the wetlands could be undertaken simultaneously; cities like New York, Singapore and some other cities are literally living on water like Lagos, but yet have their wetland zones in its natural state because of adequate conservation laws and planning. These had resulted into direct habitat loss, suspended solids additions, hydrologic changes, altered water quality, increase runoff volumes, diminished infiltration; reduce stream base flows and groundwater supplies, prolonging dry periods to mention just a few. Urbanization is one of the severe Land Use/ Land Cover (LULC) change agents, especially in rapidly urbanizing developing countries such as Nigeria. Land use/land cover is among the key drivers of environmental change as it leads to dramatic changes in both landscape patterns and ecosystem functions.

Lagos metropolis, the nation's economic nerve center, is on a low-lying coastal landscape endowed with lagoons, wetlands, and other ecological assets. With rapid urbanization and intense development pressure, some of the fringing wetlands and other land cover in the area have been converted to urban landscape. The study seeks to establish that urbanization in the metropolis results from influx from the rural areas which had resulted in the quest for more spaces to provide accommodation or employment for the ever increasing population. And lastly, draw attention for the urgent need to protect and preserve wetlands in the study area.

1.2 STATEMENT OF PROBLEM

In developing countries where rural-urban migration is on the increase, and urban population boom is inevitable, urban land use is essentially used for residential purpose and other developmental purposes. This backed with the inadequate implementation of town and regional planning laws as well as lack of political will to address some pertinent planning issues has resulted in haphazard developmental planning. These developments cares less about ecologically fragile environments such as wetlands, coastal environment and floodplain of natural water course by encroaching on the regulatory setbacks for such natural features, thus reducing their retention capacity.

Therefore due to population increase as a result of urbanization, there has been high demand on the little available land around and within the wetland region which variably causes pressure on the wetland products (i.e. fish, peat etc). This is very evident as a result of different anthropogenic activities such as incessant sand filling so as to acquire more land for housing and other economic activities, increase in the numbers of trees felled in wetland as wood for fuel, which are sometimes exported to the surrounding and far away cities to meet the people’s demand and efforts are seldom made to replace the destroyed trees.

The Wetlands around Ikorodu Local Government Area (LGA) of Lagos State remain unprotected due to rapid landuse changes over the past years as a result of increase in population. The fact that information on wetland in Ikorodu LGA is very minimal has consequently led to inadequate or lack of planning. These had resulted into direct habitat loss, changes in landscape and decrease in biodiversity, increased exposure of land surface to water and wind erosion which may lead to flooding of the area, reduced ground water supplies, diminished infiltration, and also less trees for human use for food, construction etc.

1.3 AIM AND OBJECTIVES

The aim of this study is to evaluate the spatio-temporal wetland changes over time for the study area to achieve the aforesaid research aim and the following objectives are pursued;

1. To map and generate a temporal data of the wetlands for the static years in Ikorodu LGA between a 21 years period (1990 - 2011).
2. To evaluate the spatial extent of wetland loss within the selected period for the study.
3. To evaluate some of the environmental impact of wetland loss in the area of study.
4. To identify major anthropogenic activities depleting wetlands in the area under study.

1.4 RESEARCH QUESTIONS

The research questions include the following:

1. At what proportion is wetland distributed in the study area?
2. What are the effects of urban sprawl on wetland?
3. Are there any environmental implication arising from wetland loss?
4. What is the major land use land cover (LULC) that is replacing the wetland?

1.5 SIGNIFICANCE OF STUDY

Most of the world's environmental issues and global changes are attributed to land use and land cover changes (especially wetland). Wetland loss takes place under the influence of a number of driving forces such as population sprawl, technology, political and socio-economic changes, and all at a regional level of spatial desegregation. Urbanization has been identified as one of the major factors that aggravate wetland loss especially in Africa and may hinder significant improvement in the lives of urban dwellers. This research will therefore provide a peculiar causes and consequences of urbanization. It will examine the measures to reduce one of the consequences of urbanization which is loss of wetland in urban centers. It will also identify the processes generating the urban phenomenon in the study area.

1.6 STUDY AREA

Ikorodu LGA is located approximately between latitude 6^0 37' - 6^0 45' North and longitude 3^0 3' – 3^0 5' East with a land area of about 394 sq. kilometers. It is bounded in the east and west by Epe and Kosofe Local Government Areas respectively, in the south by the Lagos lagoon, and towards the north by Ogun State.

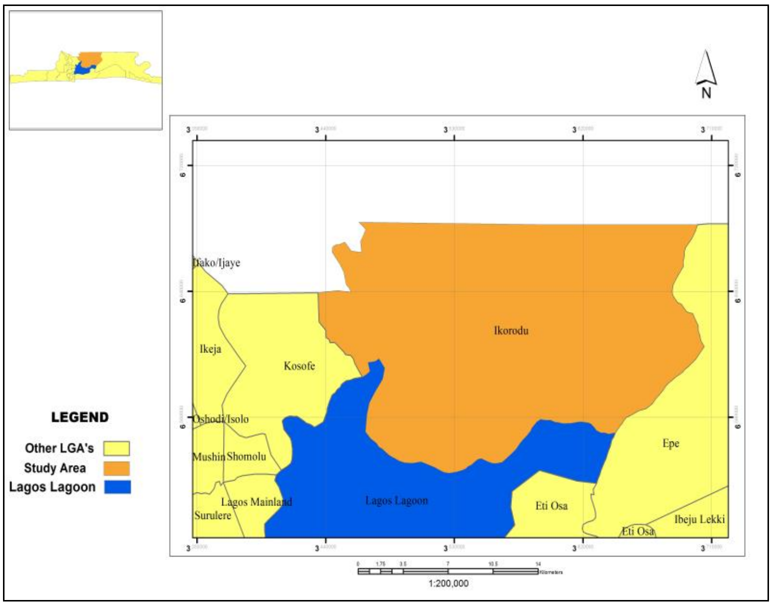

Figure 1. 1: The Study Area

2.1 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Expansion in land use and land use change (LULC) date back to pre-history and are the direct or indirect consequences of human actions to secure essential resources. This may occur as result of mismanagement of the landscape, deforestation, climate change etc, and this consequently affect land cover.

2.2 Wetlands

The Ramsar Convention definition of wetlands as 'areas of marsh, fen, peat-land or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 meters.' The recurrent or prolonged presence of water (hydrology) at or near the soil surface is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Turner, 1988).

The U.S. Fish and Wildlife Service defines wetlands as: lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water, and that have one or more of the following attributes: (1) At least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin *et al*., 1979). Oyebande et al. (2003) also grouped wetland ecosystems into three broad categories, namely: freshwater, man-made and saltwater wetland ecosystems.

Physical changes in the hydrological cycle (driven by both climate change and human modification of the systems) in the case of reduced rainfall and/or increased evaporation would disconnect rivers from their floodplains and wetlands and slow water velocity in riverine systems, converting them into a chain of connected reservoirs or pools. These in turn impact the migratory patterns of fish species and the composition of riparian habitat, opens the way for exotic species, and contributes to an overall loss of freshwater biodiversity and inland fishery resources and agricultural productivity of traditional systems and ecosystems long adapted to the flood regime.

Climate change is expected to impact adversely on wetland functions through change in hydrology, biogeochemistry and biomass accumulation. Particularly, climate change is expected to cause melting of sea ice, rise in sea levels, change in oceanic circulation patterns, species extinction, salt water intrusion, loss of habitat, higher storm frequency and intensity, flooding in the coastal regions, amongst others (Dietrich, 2005; Kusler, 2003). The combined adverse effects of mineral exploitation and climate change are enormous, hence the need for serious studies to protect wetlands.

2.3 Wetlands Resources of Nigeria

Nigeria is naturally endowed with abundant surface and groundwater resources, but the water supply situation in the country for various uses remains far below expectation (Uluocha & Okeke, 2004). Aggravating the problem of water management in the country is the fact that wetlands, which naturally recharge and protect both the surface and groundwater resources, are being unscrupulously degraded at a rather alarming rate (Uluocha & Okeke, 2004). Nigeria is richly endowed with abundant wetlands ecosystem, the majority of which are found in the Niger, Benue and Chad basins **Figure 2. 1** below. Oyebande, *et al.,* (2003) and Asibor, (2009), identified fourteen (14) major wetland belts in Nigeria.

These includes: Sokoto-Rima, Komadugu Yobe, Lake Chad, Upper Niger and Kainji Lake, Middle Niger – Lokoja - Jebba – Lower Kaduna, Lower Benue – Makurdi, Cross River, Lower Niger, Niger Delta, Benin – Owena and Okomu, Lagos Lagoon and Lekki Peninsula, Lower Ogun River, Ologe Lagoon, Badagry and Yewa Creeks and the trans-boundary wetlands of the Upper Benue. Despite the existence of many important wetlands in Nigeria, most of them are not well documented and gazzetted (Chidi & Ominigbo, 2010). For example, in the entire country, only eleven (11) wetland sites are recognized as Ramsar sites, both inland and coastal (Asibor, 2009). These wetlands are however at the risk of degradation and biodiversity loss resulting from urbanization, climate change and mineral exploitation and processing (Uluocha & Okeke, 2005; Akpofure, 2009; Asibor, 2009).

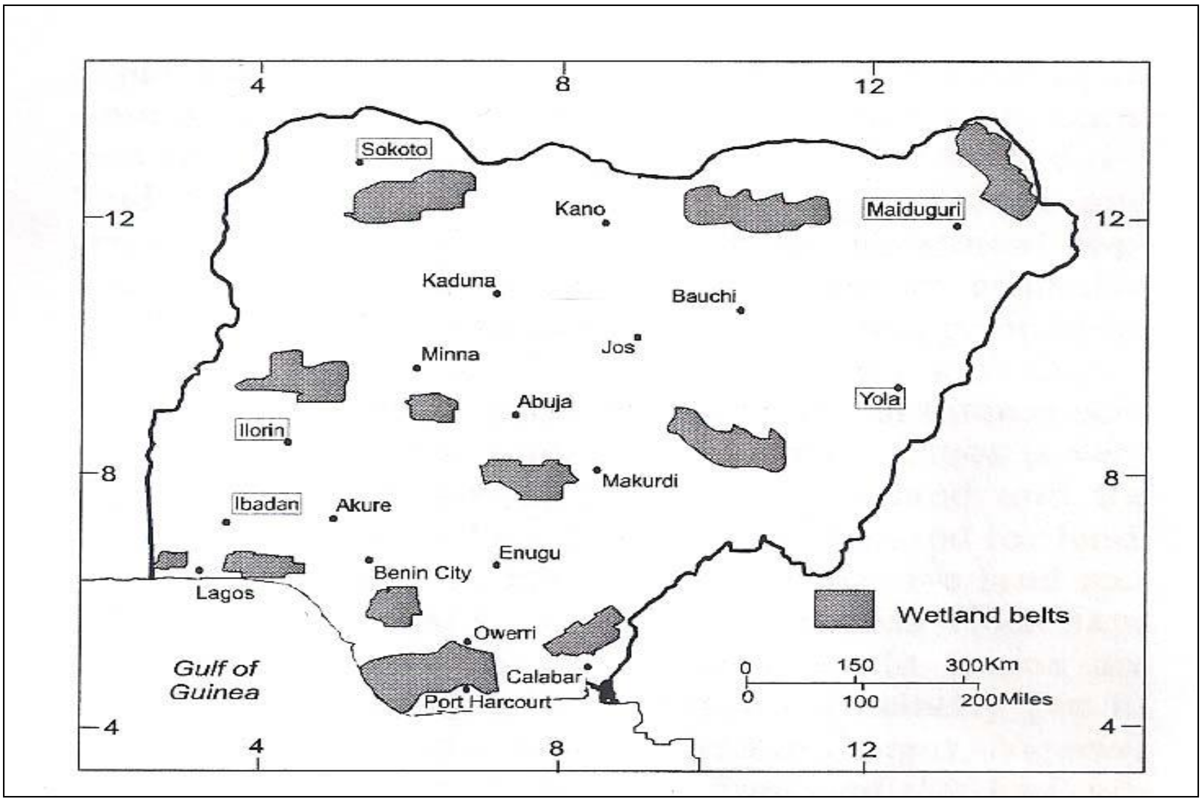

Figure 2. 1: Map of Nigeria Showing Wetland Belts.

Source: (Uluocha & Okeke, 2004).

2.4 Identification of Wetlands

The NAS (1995) report provides a definition for "wetlands" as well as criteria for identification and indicators of wetland conditions. The identification exercise is through on-site or the off-site approaches.

2.4.1 <u>On-site Identification</u>

The indicators of the presence of a wetland are hydro-phytic vegetation (plant life growing in water, soil, or on a substrate that is periodically deficient in oxygen due to excess water), presence of water, and hydric soils (soils saturated, flooded, or ponded, long enough during the growing season to develop anaerobic conditions in the upper profile). Observations of field indicators are used to determine whether the criteria are satisfied since the criteria alone may not be enough to document presence of a wetland.

In particular, flooding or saturated soil conditions may occur for only a short time during the year, and generally not when delineators are present. For an ecological determination of the presence of a wetland, all that may be required is the presence of hydro-phytic vegetation that require flooded or saturated conditions for survival. Such vegetation is outcompeted by upland species when wetlands are drained. Wetlands require permanent or periodic inundation or soil saturation at the surface for a week or more during the growing season to be a wetland ecologically as well as for jurisdictional purposes.

2.4.2 Off-site Identification of Wetlands

Off-site identification of wetlands can be a useful screening tool to determine the possible existence of wetlands. However, on-site verification is necessary to establish the existence, size, shape, and type of wetlands (NAS, 1995). Some resources for offsite identification of wetlands include:

Topographic Maps: These maps portray vegetation cover types, surface features, rivers, lakes, canals, submerged areas, and bogs. The term 'land subject to inundation' indicates floodplain areas. In the words of NAS (1995), the topographic Maps allow historical evaluation of a site, which can be useful for restoration purposes. Small wetlands, however, are often not included because of their size and the scale of the maps

Remotely sensed Data: Aerial photos and satellite imageries provides a good source of data compilation on wetlands, which serves as a good means of mapping and generating inventory on existing wetlands. Aerial photography has been used to map wetlands for at least three decades (Gammon and Carter, 1979; Johnston, 1991). The Federal Geographic Data Committee in NAS (1995) has published a review of the use of satellite data for mapping and monitoring wetlands, based on the experience of several private and public agencies.

2.5 Wetland and its Classification

Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydro-phytic vegetation usually is established, although alluvial and tidal flats may be non-vegetated. Wetlands frequently are associated with topographic lows, even in mountainous regions. Examples of wetlands include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and manmade impoundments such as reservoirs.

They include wet meadows or perched bogs in high mountain valleys and seasonally wet or flooded basins, playas, or potholes with no surface-water outflow. Shallow water areas where aquatic vegetation is submerged are classed as open water and are not included in the Wetland category. Remotely sensed data provide the primary source of land use and vegetative cover information for the more generalized levels of this classification system. Vegetation types and detectable surface water or soil moisture interpreted from such data provide the most appropriate means of identifying wetlands and wetland boundaries.

Inasmuch as vegetation responds to changes in moisture conditions, remote sensor data acquired over a period of time will allow the detection of fluctuations in wetland conditions. Ground surveys of soil types or the duration of flooding may provide supplemental information to be employed at the more detailed levels of classification. Two separate boundaries are important with respect to wetland discrimination: the upper wetland boundary above which practically any category of land use or land cover may exist, and the boundary between wetland and open water beyond which the appropriate water category should be employed.

2.5.1 Forested Wetland

Forested Wetlands are wetlands dominated by woody vegetation. Forested Wetland includes seasonally flooded bottomland hardwoods, mangrove swamps, shrub swamps, and wooded swamps including those around bogs. Because Forested Wetlands can be detected and mapped by the use of seasonal imagery, and because delineation of Forested Wetlands is needed for many environmental planning activities, they are separated from other categories of Forest Land.

2.5.2 Non-Forested Wetland

Non-forested Wetlands are dominated by wetland herbaceous vegetation or are non-vegetated. These wetlands include tidal and non-tidal fresh, brackish, and salt marshes and non-vegetated flats and also freshwater meadows, wet prairies, and open bogs. The following are examples of vegetation associated with non-forested Wetland. Narrow-leaved emergent such as cord grass (*Spartina)* and rush (*Juncus*) are dominant in coastal salt marshes.

2.6 Urbanization

Urbanization is the process by which urban areas increase in size and population density. A city is the biggest and the most populated urban area. The largest and fastest growing cities are in the developing countries of Africa, Asia, and Central and South America. Currently about half of the world population is urbanized and this is expected to increase to 80 - 90% in the future (Cunningham and Saigo, 1990). Urbanization is inter-twined into the process of evolution of a city as it grows from rural to metropolitan status. A modern city like Lagos is to perceive as a complex institution with multiple problems. Such problems may have physical, social, economic, political and cultural dimensions. Sometimes urbanization is fallout of a city's technological advancement. Urbanization and its attendant air pollution, and other human economic activities have, in the last 100 years, contributed to an increase in the concentration of greenhouse gases in the atmosphere leading to the enhanced greenhouse effect which in turn resulted in climate change arguably the most important and dangerous and certainly the most complex environmental issue to date.

2.7 Land Use and Land Cover (LULC)

In the past two centuries the impact of human activities on the land has grown enormously, altering entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate. A major international initiative to study land-use and land cover change, the LULC project, has gained great momentum in its efforts to understand driving forces of land-use change (mainly through comparative case studies) and develop diagnostic models of land cover change (de Sherbinin, 2002). Knowledge about land use and land cover has become increasingly important as the nations plan to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat (Anderson *et al.,* 1976).

Accounting for the changes in land cover over time in any region is one way to take care of the pattern of resource consumption and to take effective steps for regional development in the wake of number of socioeconomic issues triggered by increase in population. A modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one such aspect, but knowledge about land use and land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat.

The variety of land use and land cover data needs is exceedingly broad. Current land use and land cover data are needed for equalization of tax assessments in many States. Land use and land cover data also are needed by Federal, State, and local agencies for water- resource inventory, flood control, water-supply planning, and waste-water treatment. Many Federal agencies need current comprehensive inventories of existing activities on public lands combined with the existing and changing uses of adjacent private lands to improve the management of public lands.

Changes in land use patterns impact significantly local and global environmental conditions as well as economic and social welfare. An understanding of how these factors influence land use patterns would provide new dimensions to policy making and public policy evaluation (Chakir and Parent, 2008). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Macleod and Congation (1998) identified four aspects of land use change detection that are important this this research tends to adopt:

a. Detecting the changes that have occurred,
b. Identifying the nature of the change,
c. Measuring the area extent of the change and
d. Assessing the spatial pattern of the change.

2.8.1 Application of Geospatial Technology in LULC Studies

Land use and land cover are important phenomenon in understanding the interactions of human activities within its environment. In order to manage these phenomena, it is necessary to map different themes from time to time (Oyinloye *et al*., 2011). The ability to forecast land use and land cover change and ultimately to predict the consequence of change will depend on our ability to understand the past, present and future state of land use and land cover change. This ability is enabled through the use of multi temporal remote sensing data and or aerial photographs which provides valuable information natural resources like land, water, forests urban areas and infrastructure facilities such as road network, river network etc. A systematic understanding of changes in land use and land cover is critical to the understanding of the ecosystem functioning and services and human welfare. A spatially explicit study of land use and land cover changes can only lead to a better understanding of the causes of change and their consequences on the environment and society.

Geographic Information System (GIS) and remote sensing provide the medium for the integration of spatial data. GIS and remote sensing have been widely recognized as an effective tool for planning and decision-making tasks. They allow for effective storage, manipulation and analysis of geographical data (Konency, 2003; Fazal, 2008). Satellite image data provides the potential to obtain land cover information at more frequent intervals and more economical than those obtained by traditional methods (Lui and Mason, 2009; Bhatta, 2010). The advantages of satellite dataset compared to aerial photography include regular repeat coverage, recovering data from the same area at the same time of the day, consistence scale and look-angle, and lower cost (Lillesand, Kiefer and Chipman, 2008). Thus, the study seeks to assess the spatio-temporal changes in wetland in the area of study which is mainly due to the impact of urbanization, and also the magnitude and trend of these changes from 1990 - 2011.

3.1 METHODOLOGY

To assess wetland changes in terms of rate, trend, direction and magnitude of change, to monitor the state of the remaining wetlands, the driving forces and health implications of the changes and to ensure their sustainable management. In wetlands, the task of collecting information by ground inventory is extremely difficult, time consuming, and therefore expensive. Remote sensing offers an attractive means of obtaining data for detecting wetland changes and updating management plans. This research involved the integration of remote sensing techniques with a Geographic Information System (GIS) framework to get information on the area under study using a PC-based image processing and analysis using ENVI 4.5 and ArcGIS 10.1 software.

3.2 Data Sources and Characteristics

The research made use of both spatial and non-spatial (attribute) data. The spatial data include LANDSAT imageries and administrative maps, while the non-spatial data includes special names of wetland, population figures etc. Sources of the study data includes;

Table 3. 1: Data sources and properties

S/N	Data Type	Source	Extent/ Path&Row	Scale/ Resolution	Date Captured
1	LANDSAT Image (TM) 1990	www.glovis.usgs.gov	191/055	30m	27/12/1990
2	LANDSAT Image (ETM+) 2000	Lab 103 GCLME	191/055	30m	6/2/2000
3	LANDSAT image (ETM+)	Lab 103 GCLME	191/055	30m	3/1/2011
4	Administrative map of Lagos	OSGOS Lagos State	-	1:50000	-

The dates of the satellite images used were deliberately picked to maintain a minimum of at least 3,300 days spacing or intervals, so as to allow for enough change to take place. The band combination adopted (i.e. bands 3, 4 & 5) was chosen because the main features of interest were more pronounced in this combination (i.e. wetland and built-up).

3.3 Procedures

The following procedures depicted by the methodological framework were undertaken to carry out the work study;

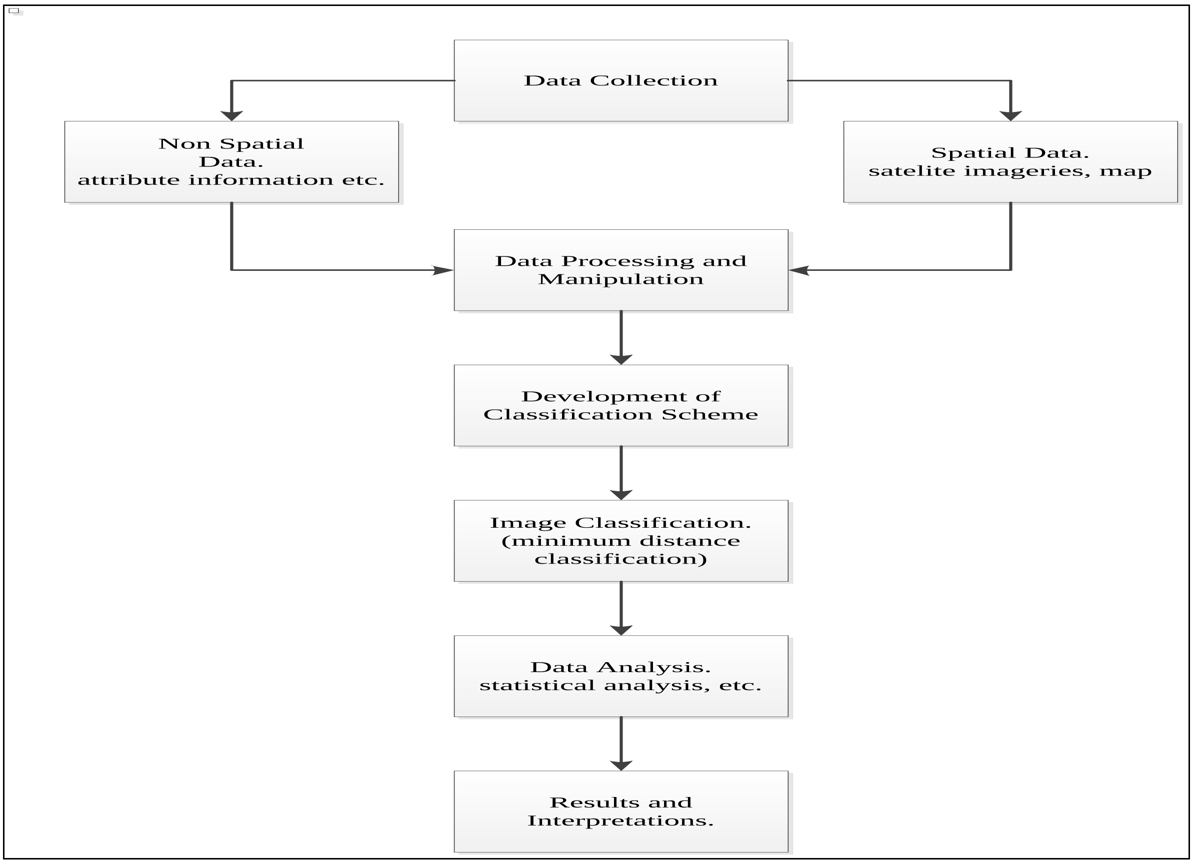

Figure 3.1: Methodological Workflow Chart

3.3.1 Data Processing and Manipulation

The main procedures that were adopted in this study include remote sensing and GIS, statistical analysis and inferences or prediction of implication. Before carrying out any of these objectives the study area was defined by clipping out rectangular region of interest (ROI) from the various bands of the scene to get the study area.

3.3.2 Description of Land Use/ Classification Scheme

Based on observation and general information gained during the research process, it was decided to focus on the following major land use and land cover classes summarized below:
Table 3. 2: The land use classification scheme

S/No	Class	Description
1	Forested Wetlands	Forested Wetlands are wetlands dominated by woody vegetation. Forested Wetland includes seasonally flooded bottomland hardwoods, mangrove swamps, shrub swamps, and wooded swamps including those around bogs. etc
2	Non-Forested Wetland	Non-forested Wetlands are dominated by wetland herbaceous vegetation or are non-vegetated. These wetlands include tidal and non-tidal fresh, brackish, and salt marshes and non-vegetated flats and also freshwater meadows, wet prairies, and open bogs. etc
3	Built-Up Areas	Parcels of land developed for dwelling purposes(residential), commercial, markets, schools, banks, roads, railroads.etc. And other urban areas with human activities
4	Water body	Streams, rivers and inland waters
5	Bare Surface	Refers to those land surface features devoid of any type of vegetation cover or structures.
6	Vegetation	Agricultural lands, forests and other vegetation classes

3.4 Image Classification

Image classification is a process by which pixels are labeled in accordance to the spectral signatures and are identified to become a certain class. In this way picture elements, shortened as pixels, are identified and the regions that have similar properties, digital numbers, DN's are indicated in the same way. There are two types of image classification namely; the supervised and unsupervised classification. Supervised classification is a process where training sets are selected from the image the data to depict sample areas of the classified features using a remote sensing skill or technique.

Image enhancement was carried out using ENVI 4.5 by loading bands 3 (red), band 4 (green) and band 5 (near infra-red) to form a combination of false color composite to depict features for built-up areas, vegetation, wetland, water and other features. The minimum distance form of supervised classification was used for the classification of all the regions of interest in the feature class. To vectorize the extracted features in raster format, a post classification operation was executed for all LULC classes, which are in a total of six (6) classes, were saved by exporting them to shape file so that the file can be used in ArcGIS environment.

3.5 Minimum Distance Classification

Specifically in minimum distance classification a sample (i.e. group of vectors) is classified into the class whose known or estimated distribution most closely resembles the estimated distribution of the sample to be classified. The measure of resemblance is a distance measure in the space of distribution functions. This method is one of the most efficient types of classification, and so was used for this study.

3.6 Data Analysis

Digital image classification was deployed using the supervised classification method. Minimum distance supervised classification of the Envi 4.5 software was used to classify each of the three imageries, after which they were converted to vector and then exported to the ArcGIS environment for area and other statistical analysis.

3.6.1 Multi-temporal mapping of wetlands

The mapping of the study area at different time period (1990, 2000 and 2011) was done within the ArcGIS software as afore-mentioned, also analysis in form of areal extent were derived from the attribute table of the ArcGIS software.

3.6.2 <u>Spatio-temporal change detection Analysis</u>

The change detection method used in this study is the 'Area Analysis method'. This involves the analysis which highlights the trend and rate of different land use (LU) changes over the period under assessment. There are three (3) levels embarked on in computing the change detection for each LU by area statistics which involves;

i. The first stage involves the calculation of the magnitude of change and this is done by subtracting observed change of each period of the years from earlier periods of the years.
ii. The next step is the calculation of the percentage change of each of the land use (trend), this was achieved by subtracting the percentage change of the previous land use from the recent land-use, divided by the previous land-use and multiplied by 100. Consequently this will help assess at a glance, the spatial extent of LU gained or lost.
iii. Finally, the last step involves the calculation of the annual rate of change by dividing the percentage change by 100 and multiplied by the number of the study years, which is 21

years in this case (i.e. 1990 - 2011). This will however show the rate at which different LU is either *gaining* or *losing* in terms of areal extent.

3.7 The Nature of Landuse/ Landcover Changes (LULCC)

The nature of LULCC refers to the identification of 'what LULC is changing to, and from what to what? Nature of LULCC information helps in highlighting the spatial or locational stability of the LULC over time, also it reveal changes that are desirable or undesirable and the response of the resource base to management decisions. The nature of changes has been examined in this study in terms of:

(i) LULC stability (areas of LULC with no change);
(ii) Areas of LULC classes gained by other classes; and
(iii) The areas of LULC classes lost to other classes.

Losses to a class indicate an encroachment on that particular class at time t_1 by other class(es) at time t_2. In the same way, gain to a class is an emergence of that particular class on other class(es) at a later time; while no change areas indicate the spatially consistent or unchanged part of a particular LULC.

4.1 DATA RESULT AND ANALYSIS

The results presented and analyzed below in this section represent the spatial coverage of land-use/ land cover especially wetlands and urban sprawl over time under investigation and these were generated using the various methods stated in the methodology section of this paper and are in line with the aim and objectives of this research work. Landsat TM and Landsat ETM+ data have been classified for the study area and analyzed to evaluate wetland changes between the years 1990 and 2011. The classification result has been divided into three parts. The digital image classification maps, graphical view of the classification results and finally comparisons and discussions.

4.2 Land-Use/ Land Cover for 1990, 2000 and 2011.

Since few selected land uses cannot be studied in isolation, thus the need to wholly consider LULC in the study of wetland and its depletion by urbanization. The area extents of LULC for the years under investigation are presented in Tables, while maps show the spatial distribution of the static Land-use/ Land cover of the study area in 1990, 2000 and 2011 respectively. The graphical representation of Table: 4.1 as presented below in figure: 4.1.

Table 4. 1: LULC for 1990, 2000 and 2011.

Classes	1990 Area (Sqkm)	Area (%)	2000 Area (Sqkm)	Area (%)	2011 Area (Sqkm)	Area (%)
Vegetation	218.01	32.81	250.24	37.66	185	27.84
Forested Wetland	157.44	23.69	46.22	6.96	42.56	6.41
Non Forested Wetland	21.63	3.26	19.01	2.86	14.42	2.17
Built up	3.12	0.47	62.62	9.42	182.25	27.43
Bare Surface	65.28	9.82	92.85	13.97	42.47	6.39
Water body	198.97	29.95	193.51	29.12	197.75	29.76
Total	**664.45**	**100.00**	**664.45**	**100.00**	**664.45**	**100.00**

Source: GIS Analysis of interpreted remotely sensed data (2014).

Table 4. 1 above, vegetation constitutes around 32.81% (218.01), 37.66% (250.24 sq.km), and 28.84% (185.00 sq.km) respectively of the entire area, also Bare Land contributes 9.82% (65.28 sq.km), 13.97% (92.85 sq.km), and 6.39% (42.47 sq.km) of the whole area and years

under consideration. Water body also covers an appreciable land area contributing 29.95% (198.97 sq.km), 29.12% (193.51 sq.km), and with 29.76% representing an area coverage of 197.75 sq.km respectively within the years under review.

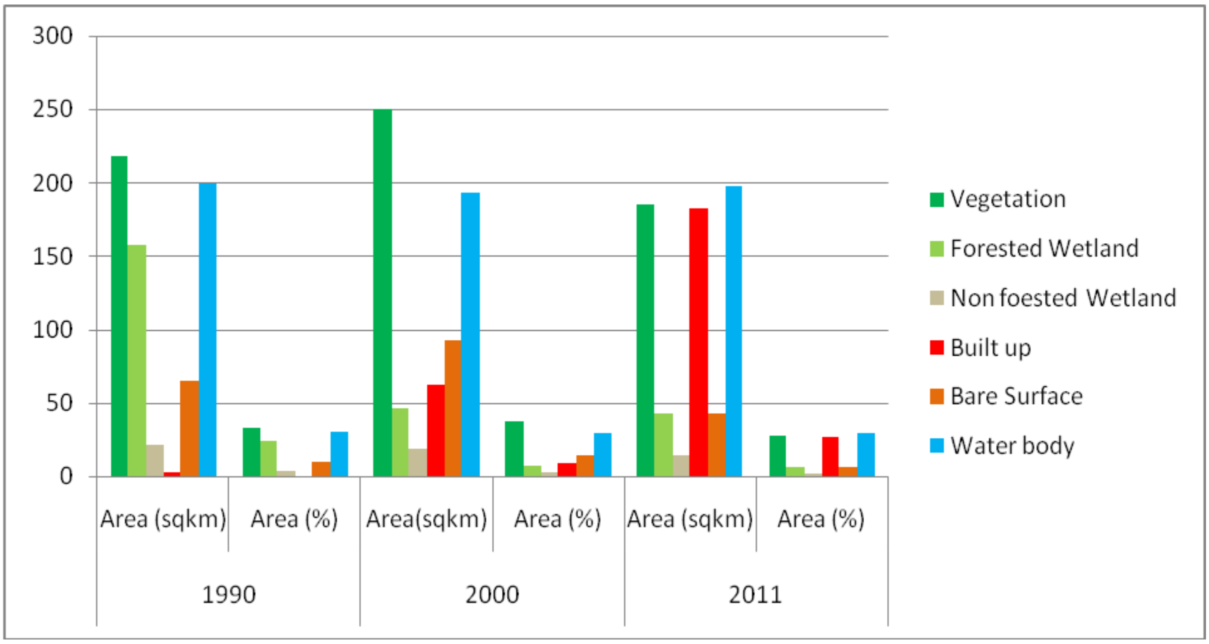

Figure 4. 1: Land-use and land-cover distribution for t_0, t_1 and t_2 (1990, 2000 and 2011).

4.3 Temporal Inventory for 1990, 2000 and 2011 Datasets

In line with the objective of the study, emphasis is given to the areal extent of wetlands (forested and un-forested) and Built up (Urban) over the three periods (i.e. t_0, t_1 and t_2) under consideration. Table 4.1 above, the entire study area covered 664.45sq.km, during this three periods investigated, Forested Wetland area recorded 157.44 sq.km which represented 23.69 % of the entire study area in 1990, 42.22sq.km (6.96%) and 42.56sq.km (6.41%) in 2000 and 2011 respectively, while Non Forested Wetland area covered 21.63 sq.km which represented 3.26 % of the entire study area in 1990, 19.01sq.km (2.86%) and 14.42sq.km (2.17%) in 2000 and 2011 respectively. Also in 1990, 2000 and 2011, Built up area covered 3.12 sq.km 0.47% of the study area, 62.62 sq.km (9.42%) and 185.25 sq.km (27.43%) respectively.

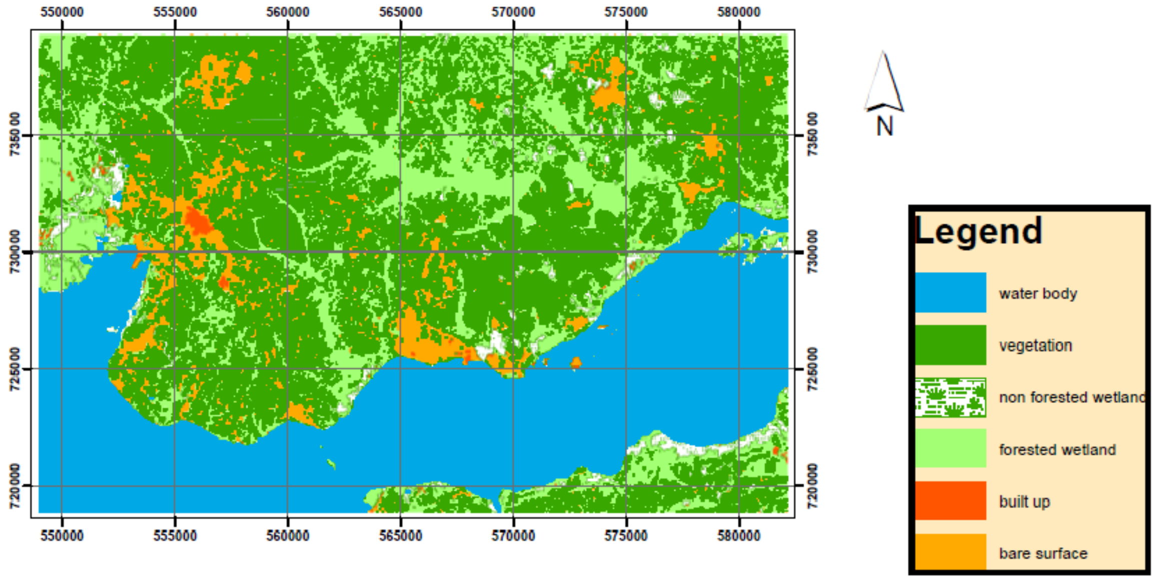

Figure 4. 2: 1990 Land-use and Landcover of Ikorodu LGA

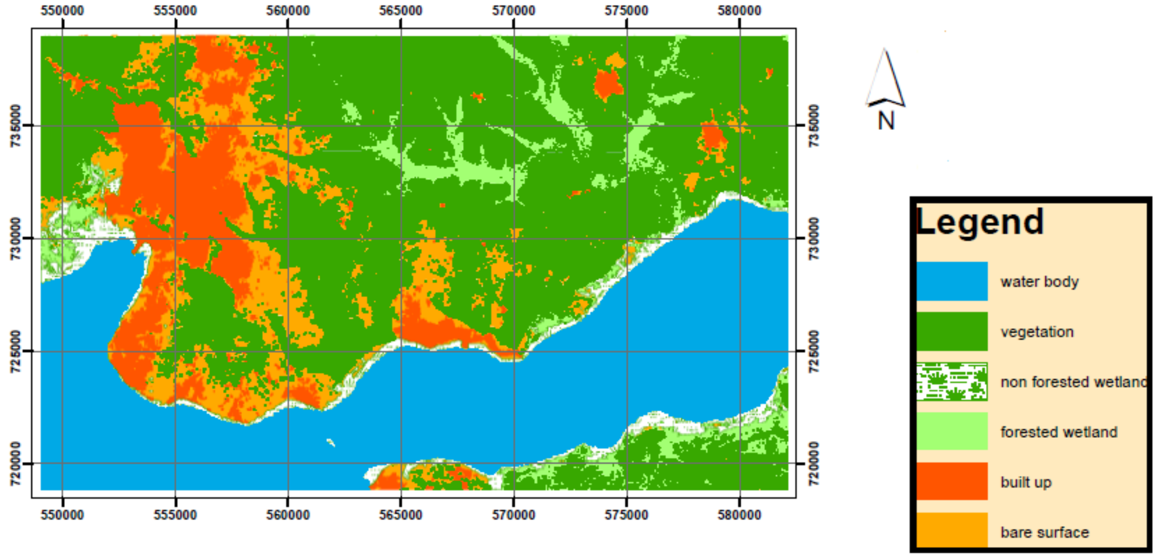

Figure 4. 3: 2000 Land-use and Landcover of Ikorodu LGA

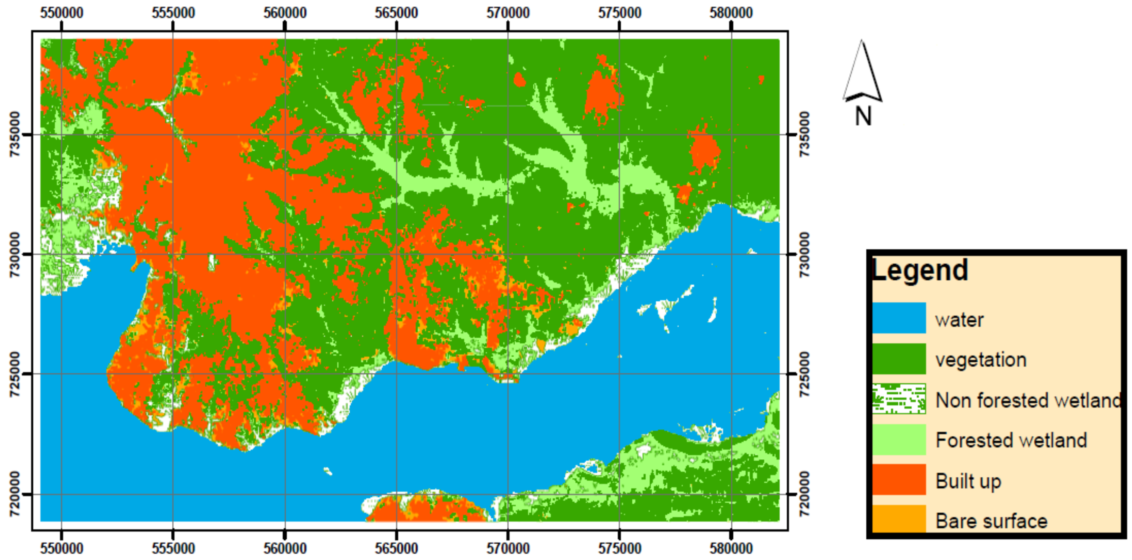

Figure 4. 4: 2011 Land-use and Landcover of Ikorodu LGA

Table 4. 2: Shows a 10 years annual rate of change between $t_0 – t_1$ (1990 - 2000).

Classes	1990 Area (Sq.km)	2000 Area (Sq.km)	Change (sq.km)	% Change	Annual Change Rate	Inference
Vegetation	218.01	250.24	32.23	**14.78**	1.48	**Increased**
Forested Wetland	157.44	46.22	-111.22	**-70.64**	-7.06	**Decreased**
Non Forested Wetland	21.63	19.01	-2.62	**-12.11**	-1.21	**Decreased**
Built up	3.12	62.62	59.50	**1907.05**	190.71	**Increased**
Bare Land	65.28	92.85	27.57	**42.23**	4.22	**Increased**
Water body	198.97	193.51	-5.46	**-2.74**	-0.27	**Decreased**
Total	**664.45**	**664.45**	0.00			

Source: GIS Analysis of interpreted remotely sensed data (2014).

Table 4. 2 above in the year 1990 - 2000 respectively, the following results were obtained. Vegetation with 218.01sq.km and 250.24sq.km recorded 32.23sq.km change in area extent during a period of 10 years and a 14.78% change and an annual change rate of 1.48. Thus a gain of vegetative cover was recorded as a result of the rejuvenation of the reclaimed Ikorodu wetlands. Forested Wetland had 157.44sq.km and 46.22sq.km recorded -111.22sq.km change in area extent with -70.64% change and an annual change rate of -7.06 recorded which was the highest loss in the period under consideration. Non forested wetland with 21.63sq.km and 19.01sq.km recorded -2.62sq.km change in area extent with -12.11% change and an annual change rate of -1.21. Built up area with 3.12sq.km and 62.62sq.km recorded 59.50sq.km change in area extent with 1907.05% change and an annual change rate of 190.71. This LULC class recorded a massive and the most pronounced increase for the period under study. Bare land with 65.28sq.km and 92.85sq.km recorded a 27.57sq.km change in its area extent at a 42.23% change and an annual change rate of 4.22. Water body with 198.97sq.km and 193.51sq.km with a change in its area extent at -5.46sq.km and a -2.74% change and an annual change rate of -0.27. As Forested Wetland accounted for a major loss, built up accounted for the greatest gain for period under review.

Table 4. 3: Shows an 11 years annual rate of change between $t_1 - t_2$ (2000 - 2011).

Classes	2000 Area (sq.km)	2011 Area (sq.km)	Change (sq.km)	% Change	Annual Change Rate	Inference
Vegetation	250.24	185.00	-65.24	**-26.07**	-2.87	**Decreased**
Forested Wetland	46.22	42.56	-3.66	**-7.92**	-0.87	**Decreased**
Non Forested Wetland	19.01	14.42	-4.59	**-24.15**	-2.66	**Decreased**
Built up	62.62	182.25	119.63	**191.04**	21.01	**Increased**
Bare Land	92.85	42.47	-50.38	**-54.26**	-5.97	**Decreased**
Water body	193.51	197.75	4.24	**2.19**	0.24	**Increased**
Total	**664.45**	**664.45**	0.00			

Source: GIS Analysis of interpreted remotely sensed data (2014).

Figure 4. 3 above in the year 2000 - 2011 respectively, the following results were obtained. Vegetation with 250.24sq.km and 185.00sq.km and recorded -65.24sq.km change in area extent during a period of 11 years and a -26.07% change and an annual change rate of -2.87. Forested Wetland had 46.22sq.km and 42.56sq.km and recorded -3.66sq.km change in area extent with -7.92% change and an annual change rate of -0.87. Non forested wetland with 19.01sq.km and 14.42sq.km and recorded -4.59sq.km change in area extent with -24.15% change and an annual change rate of -2.66. Built up area with 62.62sq.km and 182.25sq.km and recorded 119.63sq.km change in area extent with 191.04% change and an annual change rate of 21.01. This LULC class recorded a massive and the most pronounced increase for the second period under study. Bare land with 92.85sq.km and 42.47sq.km and recorded a -50.38sq.km change in its area extent at a -54.26% change and an annual change rate of -5.97 recorded, which was the highest loss in the period under consideration. Water body with 193.51sq.km and 197.75sq.km and recorded a 4.24sq.km change in its area extent at a 2.19% change and an annual change rate of 0.24. Thus there was a slight increase in the area coverage of the water body between this time periods. As Bare Land accounted for a major loss, built up accounted for the greatest gain for period under study. They were the more threatened LULC class. Since losses to a class indicate an encroachment on that particular class at time $\mathbf{t_1}$ by other class(es) at time $\mathbf{t_2}$. In the same way, gain to a class is an emergence of that particular class on other class(es) at a later time.

Table 4. 4: Shows a 21 years annual rate of change between $t_0 - t_2$ (1990 - 2011).

Classes	1990 Area (Sq.km)	2011 Area (sq.km)	Change (sq.km)	% Change	Annual Change Rate	Inference
Vegetation	218.01	185.00	-33.01	**-15.14**	-3.18	**Decreased**
Forested Wetland	157.44	42.56	-114.88	**-72.97**	-15.32	**Decreased**
Non Forested Wetland	21.63	14.42	-7.21	**-33.33**	-7.00	**Decreased**
Built up	3.12	182.25	179.13	**5741.35**	1205.68	**Increased**
Bare Land	65.28	42.47	-22.81	**-34.94**	-7.34	**Decreased**
Water body	198.97	197.75	-1.22	**-0.61**	-0.13	**Decreased**
Total	**664.45**	**664.45**	0.00			

Source: GIS Analysis of interpreted remotely sensed data (2014).

Table 4. 4 above in the year 1990 - 2011 respectively, the following results were obtained. Vegetation with 218.01sq.km and 185.00sq.km and recorded -33.01sq.km change in area extent during a period of 21 years and a -15.14% change and an annual change rate of -3.18. Forested Wetland had 157.44sq.km and 42.56sq.km and recorded -114.88sq.km change in area extent with -72.92% change and an annual change rate of -15.32 recorded, which was the highest loss in the period under consideration. Non forested wetland with 21.63sq.km and 14.42sq.km and recorded -7.21sq.km change in area extent with -33.33% change and an annual change rate of -7.00. Built up area with 62.62sq.km and 3.12sq.km and recorded 179.13sq.km change in area extent with 5741.35% change and an annual change rate of 1205.68. This LULC class recorded a massive and the most pronounced increase for the entire period under study. Bare land with 65.28sq.km and 42.47sq.km and recorded a -22.81sq.km change in its area extent at a -34.94% change and an annual change rate of -7.34. Water body with 198.97sq.km and 197.75sq.km and recorded a -1.22sq.km change in its area extent at a -0.61% change and an annual change rate of -0.13. Thus there was a slight increase in the area coverage of the water body between this time periods. As Forested Wetland accounted for a major loss, built up accounted for the greatest gain for period under study. They were the more threatened LULC class. Since losses to a class indicate an encroachment on that particular class at time $\mathbf{t_0}$ by other class(es) at time $\mathbf{t_2}$. The two wetland classes (forested and non-forested) were mainly encroached by built up areas and all other forms of urban activities springing up in the region due to urbanization.

4.4 Swat Analysis

4.4.1 Strengths

1. The researcher's in depth knowledge of the study area
2. Ability to utilize the geo-information techniques (i.e. Remote Sensing, image processing and GIS) as an application tool in solving real life problems.

4.4.2 Weaknesses

1. Limited previous academic studies on this area
2. Availability of required datasets

4.4.3 Opportunities

1. It will encourage wetland conservation in this area and creates opening for further studies by other researchers.
2. Could be utilized as a reference material to guide legislation in the future.

4.4.4 Threats

1. Time constraint in image pre-processing, processing and documentation.
2. Demands high techniques in handling readily available datasets.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

A general problem common to research and indeed researchers in social analysis is the inadequacy or sometimes the entire lack of relevant data. This research effort has not been an exception i.e. there was little or inadequate information on the wetland situations in Ikorodu LGA that could be accessed, and hence reflected in the pace at which this work was carried out. Many tropical wetlands are being directly exploited to support human livelihoods as in the case of wetlands within the study area. It should be noted that such use or conversion of wetlands for various purposes connotes change in LULC which can be study under land-use science. Primary causes of wetland loss in Lagos Metropolis are human activities which include incessant deforestation and land reclamation for conversion of wetland environment to economic uses (construction) and perennial flooding that are common and regular occurrences in the metropolis.

5.2 Conclusion

The completion of this study has demonstrated the relevance of spatial planning employing image processing analysis and geo-information in revealing wetland loss within the study area. It is important to restate the overall objectives of this study are as follows; firstly, *to map and generate a temporal data of the wetlands for the static years in Ikorodu LGA between a 21 years period*. Secondly, *to evaluate the spatial extent of wetland loss within the selected period for the study*. Thirdly, *to evaluate some of the environmental impact of wetland loss in the area of study* and fourthly, *to identify major anthropogenic activities depleting wetlands in the area under study*. Therefore to achieve these objectives, relevant research works were reviewed to answer the four research questions.

In estuarine ecosystem inventory such as the Ikorodu wetlands for its preservation management small scale classification maps were produced using the temporal LULC classification extract. Remotely sensed data offers an alternative measurement of vegetative characteristics that provides a more synoptic view to remote terrain. Since multispectral data serves to retain good spectral resolution the pan chromatic band 8 provides improved spatial resolution. The use of co-registered multispectral data was essential for creating colour composite and classification images. Therefore, monitoring wetland loss or urban growth requires acquisition of multi-temporal datasets useful for monitoring temporal changes.

Potential users of this technology should note that computer aided analysis is data driven, rather understanding the limitations and capabilities of results obtained from these systems. Therefore, such data dependent results can be no better than the quality of the form which it was derived without assumptions. The present environmental situation of this local area is rapidly changing as a result of induce human activities. This region has lost huge amount of wetlands for the twenty one (21) years under review, a loss of 122.09sq.km from forested and non-forested wetlands was recorded as a result of deforestation for creating peri-urban settlements. The sprawling peri-urban settlement (built-up areas) was a major contributor which accounts for an approximate 179.13sq.km change in area extent with 5741.35% change and an annual change rate of 1205.68.

This study has shown how potent and influential remote sensing can be; especially by use of remotely sensed satellite datasets in mapping wetland, urban sprawl, LULC and change detection as a whole. On Ikorodu LGA, the trend and rate of land use, and most importantly urban encroachment on wetland over a period of 21 years was achieved. Since LULCC change is an inevitable outcome of man environment interactions. However, while gradual land cover change may be acceptable, naturally-induced drivers, rapid land cover change with its attendant negative socio-economic and environmental consequences would be unacceptable.

Since the driving forces of future LULC would be demographic changes, economic growth and technological development, then it is the responsibility of man (the initiator of these changes) to be well guided in its developmental activities. One such requirement necessary for guided and control development is through the understanding of land cover and land use change patterns. Therefore some important information can be integrated into any developmental policies and implementations, especially relating to Wetland and Urbanization.

RECOMMENDATIONS

Further study on this area is recommended to validate the results obtained from this study. Hence the data processing techniques to be used should be done taken account of the problems encountered in this study. The Geographic Information System, Remote Sensing approach and image processing approach should be employed for seasonal map updating as a means of monitoring construction activities on this endangered land forms. Higher resolution datasets are therefore recommended for effective discrimination amongst all land-uses of interest.

It is recommended that a detailed land use/ land classification system should be designed for effective monitoring, mapping and management of land-use activities within the city. National policies which support wetland conservation and promote appropriate legislation should be developed. National and Regional Wetland Conservation programs should be supported; also National Wetland Committee should be established so as to improve the qualitative and quantitative information on National ecosystems. Environmental Impact Assessment before any major industrial project is sited is very essential. This approach will leverage on works in other researchers and incorporate the indigenous views on the adverse impacts of industrialization on wetlands within the study area.

This will reveal wetlands loss necessitated by urban encroachment into these fragile land forms. Encouraged conservation practices through public participation in government policies and such principles as part of basic science curriculum in foundation education. Having evaluated the desirability of the inclusion of remotely sensed data in mapping wetlands, it important to research on and develop measurement models for reporting purposes in Niger Delta. This model should leverage on works in other researchers and incorporate the indigenous views on the subject matter.

Implementation of Ikorodu's master plan, which specifies the regulation for especially as it affects drainage set-backs, building code and wetland protection should be adequately enforced. Also tourism should be enhanced by efforts from individuals, cooperate bodies and the government in the aesthetic development of the area by beautifying public areas and also landscaping exercises should be done. Greener environment should be encouraged by plantation of trees and flowers, since there was a significant drop in the vegetation area extent from the year 2000 - 2011, which resulted in -26.24% change and -2.37sq.km annual rate of change.

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BIOGRAPHICAL NOTES

The co-author is a Surveyor Registered by the Surveyors Council of Nigeria (SURCON). A University of London alumina whom holds an MSc. in Environmental Mapping from the department Civil, Environmental and Geo-matics Engineering (CEGE), University College London (UCL). Also holds a bachelor degree in Surveying and Geo-informatics from University of Lagos, Nigeria.

CONTACTS

Surv. Godwill Tamunobiekiri Pepple
Geospatial Technical Partners Initiatives
33, Moleye Street, Off Hughes Avenue,
Alagomeji, Yaba, Lagos,
Nigeria.
Telephone: +2348035300159, +2348181898881
Fax: Nil
Email: abie1802@yahoo.com
Web site: Nil