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Land use/ land cover classification and change detection mapping: A case study of Lagos state, Nigeria

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Abstract*— *The study attempts to determine the land use/land cover expansion that occurred in the area over a period of thirty years. Multi temporal Landsat satellite images TM 1986, ETM+ 2001, 2006 and 2018 from the United States Geological Survey (USGS) website as primary dataset.

Area of interest was clipped in ArcGIS environment and then enhanced and classified in ENVI. Using supervised classification algorithm, the images were classified into bare land, built-up area, vegetation and water body used to carry out change detection analysis or time series analysis. In-addition, figures from National Population Commission (NPC) were used. Change detection analyses was carried out on the imageries to obtain the physical expansion of the area. The Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC) were determined as well. Accuracy assessment was carried out on the images classified using the confusion matrix with Ground truth image tool on ENVI. An overall kappa coefficient was generated from this assessment which proved to be a very good result.

Results obtained from the analysis of built-up area dynamics for the past four decades revealed that the town has been undergoing urban expansion processes. There was an increase in the built-up area between 1986 and 2018 which is largely due to the increase in population of Lagos state based on its high Urbanization rate. Vegetation cover reduced between 1986 and 2001, which is reasonable considering the rate at which the built-up area was increasing. But between 2001 and 2006, vegetation increased a little, this due to farming in 2006. Bare land had an inconsistent change. The increase in bare land could be as result of bush burning while the reduction could be as a result of more farming in the state or development of more built-up areas.

It is recommended that Global change research efforts should be encouraged through international research partnerships to establish international land use /land cover science program to bridge the gap between climate researchers, decision makers and land managers; There was more reduction in vegetation than increase which poised a great danger that could cause greenhouse effect on the environment. Government at all levels should ensure that all these land use/land cover types are maintained to save our ecological biodiversity.

***Keywords*— Remote Sensing, GIS, Land use/Land cover, Satellite Imagery, Change detection.**

I. INTRODUCTION

Earth surface is being significantly altered by man and this has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use over time. Man continues to explore and exploit the natural resources in his environment and this has brought immense contribution to observable changes in land. The physical development in an urban community and the need to control such development for economic, socio-political and environmental reasons have necessitated the requirement for geographical and statistical information relating to the

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amount of land that has been used and that which is remaining (Abiodun et al, 2011).

Land use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used" (Turner et al, 1995). Land is the habitat of man and man uses land in a variety for his economic, social and environmental advancement. Land is the fundamental basis of all human activities, from it we obtain our food we eat, our shelter, our water, the space to work, the room to relax and lots more. The magnitude of land use change varies with the time being examined as well as with the geographical area. The assessment of these changes depends on the area, the land use types being considered, the spatial groupings, and the data sets used.

However, Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels. Unsupervised classification relies purely on image statistics and brightness levels to identify natural groups of pixels, without requiring any prior knowledge of the scene.

Vegetation patterns are an integrated reflection of physical and chemical factors that shape the environment of a given land area (Whittaker 1960).

Computer assisted delineation of homogeneity in the imagery and ancillary data, followed by the analyst assigning land cover labels to the homogenous clusters of pixels (Jensen, 2005).

Any given portion of Earth's surface can be observed and described in various ways, which differ but may interact according to the distance separating the observer from the observed portion of Earth's surface.

The primary units for characterizing land cover are categories (i.e. forest or open water) or continuous variables classifiers (fraction of tree canopy cover). Secondary outcomes of land cover characterization include surface area of land cover types (ha), land cover change (area and change trajectories), or observation by-products such as field survey data or processed Satellite imagery. Land cover in different regions has been mapped and characterized several times and many countries have some kind of land monitoring system in place (i.e. forest, agriculture and cartographic information systems and inventories). In addition, there are a number of global land cover map products and activities.

Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996). Land use growth models help us to understand the complexities and interdependencies of the components that constitute spatial systems and can provide valuable insights into possible land-use configurations in the future (Atanda et al, 2015). The basic premise in using satellite images for change detection is that changes in land cover result in changes in radiance values that can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computing power.

Traditional methods for gathering demographic data, censuses, and analysis of environmental samples are not adequate for multicomplex environmental studies, since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (Mallupattu et al, 2013). These technologies provide data to study and monitor the dynamics of natural resources for environmental management.

According to Meyer (1995) every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others. While land cover categories could be cropland, forest, wetland, pasture, roads, urban areas among

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others. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water (Meyer, 1995).

Land use affects land cover and changes in land cover affect land use. A change in either however is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Turner, 1995).

Land-use and land-cover changes are local and place specific, and they currently become one of the most important facets of global environmental change. Land-use and land-cover changes mainly refer to replacing forests and grassland for agricultural use, intensifying farmland production and urbanization. Humans have been altering land cover since pre-history through the clearance of patches of land for agriculture and livestock. (Shi, 2008). Variations promoted by anthropogenic activities include substituting forests and grassland for agriculture use, intensifying farmland production and urbanization. Land-use and land-cover change induced by both human activities and natural feedbacks have converted large proportion of the planet’s land surface. (Shi, 2008). In the past two centuries the impact of human activities on the land has grown significantly, altering entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate.

Expansions in land use and land cover change date to prehistory are the direct and indirect consequence of human actions to secure essential resources. This occurs as a result of deforestation and management of the landscaping. The causes of LULC (Land use land cover change) are: biodiversity loss and population. By convention on biological diversity, biodiversity is defined as “the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems are the ecological complexes of which they are a part, this includes diversity within species, between species and of ecosystems (Lloyd, 2011). In terms of population, In the face of increasing urban population, there is inadequate supply of housing and infrastructure for the teeming population, as a result, the existing infrastructure and housing are overstressed, while unsanitary living conditions characterized by filthy environment, unclean ambient air, stinky and garbage filled streets and sub-standard houses continue to dominate the urban landscape in Nigeria. The concentration of more people in urban areas of the country has brought more pressure on the land space for the production of food, infrastructure, housing and industrialization.

Available data on LULC changes can provide critical input to decision-making of environmental management and planning the future. The growing population and increasing socio-economic necessities creates a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LULC. The LULC alterations are generally caused by mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides, floods etc. The magnitude of land use change varies with the time being examined as well as with the geographical area. The assessment of these changes depends on the area, the land use types being considered, the spatial groupings, and the data sets used (Atanda et al, 2015). However, Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels (Atanda et al, 2015).

Atanda et al (2015) carried out a study of land use and land-cover change in Lagos Mainland. The work showed that the percentage of the water body was relatively high in the year 1984 but was extremely low in 2006. This might have been caused by human activities such as sand mining and dredging activities around the mainland axis.

Moshen (1999) carried out a study on the land use land cover mapping of Panchkula, Ambala and Yamunanger districts, Hangana State in India. They observed that the heterogeneous climate and physiographic conditions in these districts have resulted in the development of different land use land cover in these districts, an evaluation by digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purpose.

In an urban community, the physical development and the need to control such development for economic, socio-political and environmental reasons have necessitated the requirement for geographical and statistical information

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relating to the amount of land that has been used and that which is remaining.

There has been a significant growth and physical expansion of urban settlements occurring all over the world which in recent time has taken on more dramatic momentum in those areas that have come to be regarded as the "third world". The most notorious example of urban growth in Nigeria has undoubtedly been Lagos. Lagos has become legendary for its congestion and other urban problems. These problems have seen people migrating into Ogun state for either residential or commercial purposes since Ogun state share boundary with Lagos state. Hence, the determination of this growth and knowledge of the rate of growth is essential for adequate future planning. Coupled with the urbanization and construction projects embarked upon by Ogun State Government which is spanning the expansions of industrial, religious and residential areas of it land mass, hence, the geospatial analysis of the land use in the state was carried out in order to obtain: Up-to-date information about the terrain and features in the area and updated map showing the present information and details which would form the basis for future planning and further development of the area.

This study thereby focuses on the Land Use/Land cover of Lagos Nigeria in order to see the various land use and also the spread of Urbanization in order to detect the changes that have taken place particularly in built-up land and subsequently predict likely changes that might take place in the same area over a given period of time in the study area thereby suggesting possible solutions making use of GIS techniques and Remote Sensing approach.

II. MATERIALS AND METHODS

Nigeria is a country in West Africa, bordered by the Republic of Benin at the West, by the Republic of Niger in the North, by Chad in the North-East and by Cameroon in the East. At the South of the country, the 853 km long coastline borders on the Gulf of Guinea in the South Atlantic Ocean.

Lagos is located in the south –western part of Nigeria. It served the dual purpose of being the Commercial and administrative headquarters of Nigeria until the mid-1990s when the administrative headquarters of Nigeria was moved to Abuja. Lagos is located at latitude 6°27' N and Longitude 3°24'E. This falls just above the equator on Africa continent. The metropolitan Lagos has an area of 137,460 hectares and spreads over (3345 sqkm/1292 sqmi). The islands are connected to each other and to the mainland by bridges and landfills. Lagos has a very diverse and fast-growing population, resulting from heavy and ongoing migration to the city from all parts of Nigeria as well as neighbouring countries. According to Nigerian National Population Commission (NPC), its metropolitan area was about 9 million people in 2006.

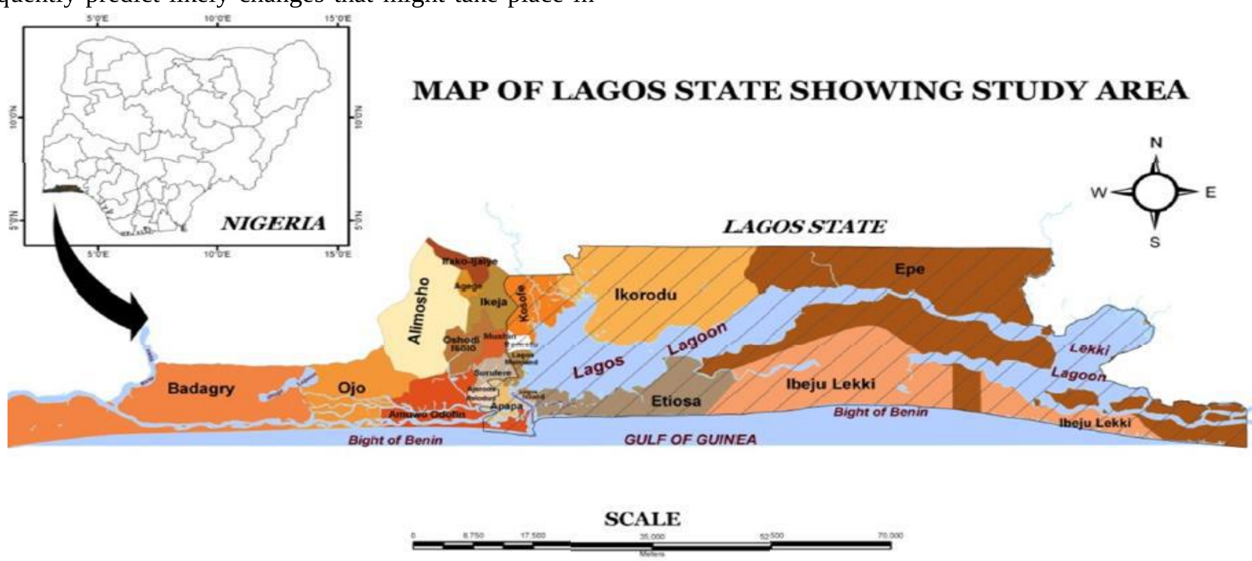

Fig.2.1: Map of the study area (Lagos State) Source: Obiefuna,2012

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2.1 Data Acquisition

The primary data was sourced from the actual fieldwork carried out in the area of study. While secondary data are data relevant from journals and articles related to this study as well as data obtained from the USGS website, research questionnaires, data vendors, among other sources. The various data types used for this project and their respective sources are given in Table 2.1.

Table 2.1: Data Types

S/N	SEGMENT	DATA TYPE	SOURCE	DATE
1	Primary Data	Google Earth Imagery	Google Earth	2018
2	Secondary Data	A digitized map of the Study Area	Researchers	2018
3	Primary Data	Satellite imagery of the Study Area with 30.0m resolution	USGS official website (www.earthexplorer.usgs.gov)	1986-2018

2.2 Image Classification

The method of classification used for the purpose of the project was the supervised classification method. Based on prior knowledge and a brief reconnaissance survey with additional information on previous research in the study area a classified scheme was developed using a supervised method. The common land use types usually classified are: Built-up, Water body, Vegetation and Bare soil.

Table 2.2: Classification scheme

S/N	Land use/cover class	Description
1	Bare soil	Uncultivated lands, open spaces, cleared and non-vegetated lands.
2	Built-up Area	Parcels of land developed for dwelling purposes
3	Water	Stream, rivers, inland water.
4	Vegetation	All types of vegetation cover.

2.3 Supervised classification

Supervised classification uses the spectral signature defined in the training set. For example, it determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum-distance classification. Supervised classification is based on the idea that a user can select sample pixels in an image that are representative of specific classes and then direct the image processing software to use these training sites as references for the classification of all other pixels in the image. Training sites (also known as testing sets or input classes) are selected based on the knowledge of the user. The user also sets the bounds for how similar other pixels must be to group them together. The method of maximum likelihood classification was used to classify the image.

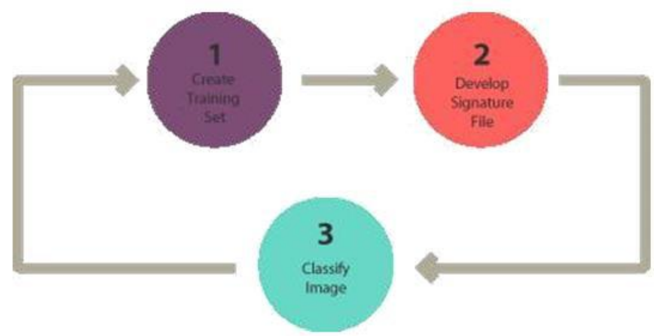

Fig.2.2: Graphic representation of supervised classification

2.4 Accuracy assessment

Accuracy assessment is performed by comparing the map created by remote sensing analysis to a reference map based on a different information source. One of the primary purposes of accuracy assessment and error analysis in this case is to permit quantitative comparisons of different interpretations. Classifications done from images acquired at different times, classified by different procedures, or produced by different individuals can be evaluated using a pixel-by-pixel, point-by-point comparison. The results must be considered in the context of the application to determine which is the “most correct” or “most useful” for a particular purpose.

In order to be compared, both the map to be evaluated and the reference map must be accurately registered geometrically to each other. They must also use the same

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classification scheme, and they should have been classified at the same level of detail.

2.4.1 How to Interpret Kappa

Kappa is always less than or equal to 1. A value of 1 implies perfect agreement and values less than 1 imply less than perfect agreement. In rare situations, Kappa can be negative. This is a sign that the two observers agreed less than would be expected just by chance. Here is one possible interpretation of Kappa.

- Poor agreement = Less than 0.20
- Fair agreement = 0.20 to 0.40
- Moderate agreement = 0.40 to 0.60
- Good agreement = 0.60 to 0.80
- Very good agreement = 0.80 to 1.00

2.5 Change Detection

This is carried out to find out how much each of the feature class has changed over time in terms of area. One of the most rudimentary forms of change detection is the visual comparison of two images by a trained interpreter. With an effective display system large enough to display both images simultaneously and to explore and digitize with a cursor tracking to the same location in both images, this is a quick method that can be used to locally collect valuable GIS compatible data while streaming the images themselves over a relatively low-bandwidth Internet connection. Digital algorithms also exist for change detection. Unclassified images can be compared on a pixel-by-pixel or patch-by-patch basis; classified images can be compared with the results indicating changes in specific classes over time. Either way, the concept seems quite simple; in practice, there are a great number of influences that must be monitored and controlled to achieve valid change detection results.

In this research, the area for each of the feature class in each epoch was computed from the classified images using the Add Area tool of their respective attribute tables in ArcMap. The area column of each of the classified images was exported to Microsoft Excel software package where change analyses (such as epoch to epoch change of each feature class, percentage change of each feature class, rate of change of each feature between epochs, etc.) was carried out along with graph presentations. Figure 3.5 shows the Overview of the change analyses in excel environment.

Table 2.3: Change Analysis of Feature class

Feature Class	Area (2018)		Area (2006)		Area (2001)		Area (1986)	
	Hectares	**%**	**Hectares**	**%**	**Hectares**	**%**	**Hectares**	**%**
Vegetation	202	53.09	235	62.28	221	58.54	224	59.41
Built-up Area	655	17.25	522	13.81	247	6.55	216	5.72
Water Bodies	634	16.67	634	16.78	678	17.95	710	18.78
Bare soil	373	9.83	269	7.13	641	16.95	608	16.10
Cloud	119	3.15	0.00	0.00	0.00	0.00	0	0
Total	3800	100	3781	100	378	100	378	100

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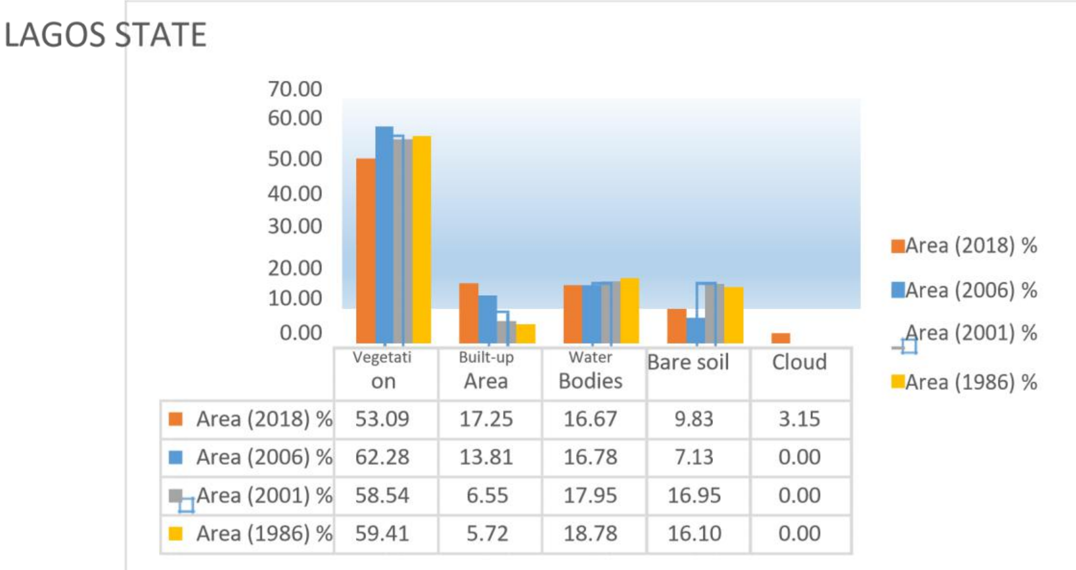

	Vegetation	Built-up Area	Water Bodies	Bare soil	Cloud
Area (2018) %	53.09	17.25	16.67	9.83	3.15
Area (2006) %	62.28	13.81	16.78	7.13	0.00
Area (2001) %	58.54	6.55	17.95	16.95	0.00
Area (1986) %	59.41	5.72	18.78	16.10	0.00

Fig.2.3: Graphic representation of percentage of change

2.6 The Land Consumption rate and Land Absorption Coefficient.

The Land consumption rate and absorption coefficient formula are given below;

$$L.C.R = \frac{A}{P} \quad \text{……………………….. equation 1}$$

A = areal extent of the city (built up area) in hectares

P = population

$$L.A.C = \frac{A_2 - A_1}{P_2 - P_1} \quad \text{……………… equation 2}$$

A_1 and A_2 are the area extents (in hectares) for the early and later years, and P_1 and P_2 are population figure for the early and later years respectively (Yeates and Garner, 1976, J.B Olaleye et al, 2012)

L.C.R = A measure of progressive spatial urbanization of a study

L.A.C = A measure of change of urban land by each unit increase in urban population. The population of the years classified for this study was also estimated using the formula represented below;

$$n = Po \times (r/100) \quad \text{………………………….. equation 3}$$

$$Pn = Po + (n \times t) \quad \text{………………………… equation 4}$$

Pn = estimated population

Po = base year population

r = growth rate of each state

n = annual growth rate (difference between two years; the year being projected and the base year)

t = number of years projecting.

III. RESULTS AND DISCUSSION

3.1 Imagery Classification Statistics and Results

The classification of the multi-temporal satellite images into built up, vegetation, bare soil, wetland and water body for the four different time periods of 1986, 2001, 2006 and 2018 has resulted in a highly simplified and abstracted representation of the study area as shown in Figures 3.1, 3.2, 3.3 and 3.4.

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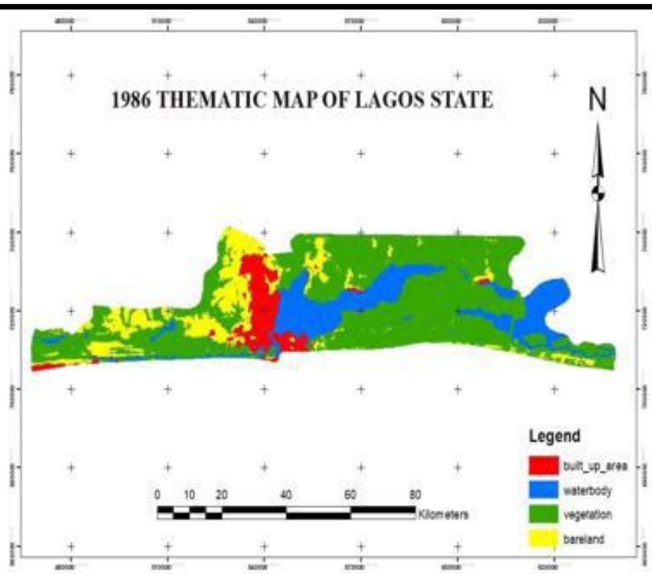

Fig.3.1: Thematic Map Of 1986

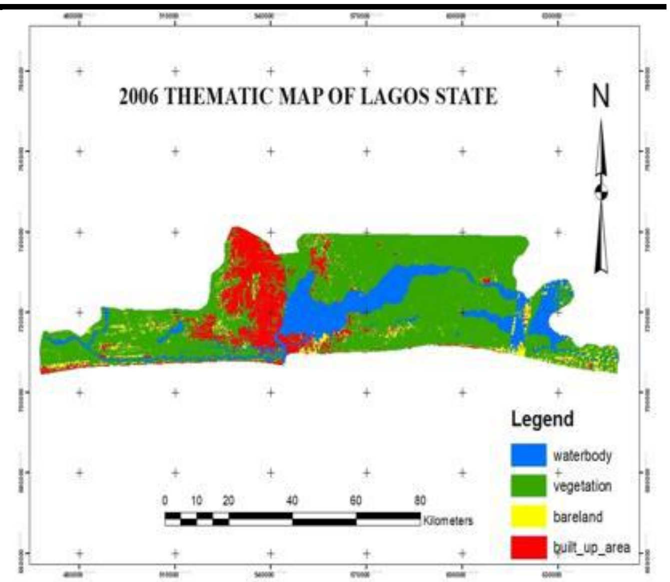

Fig.3.3: Thematic Map of 2006

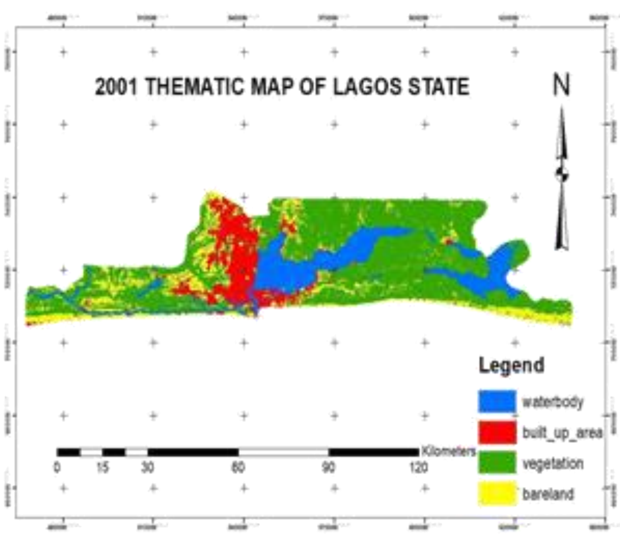

Fig.3.2: Thematic Map Of 2001

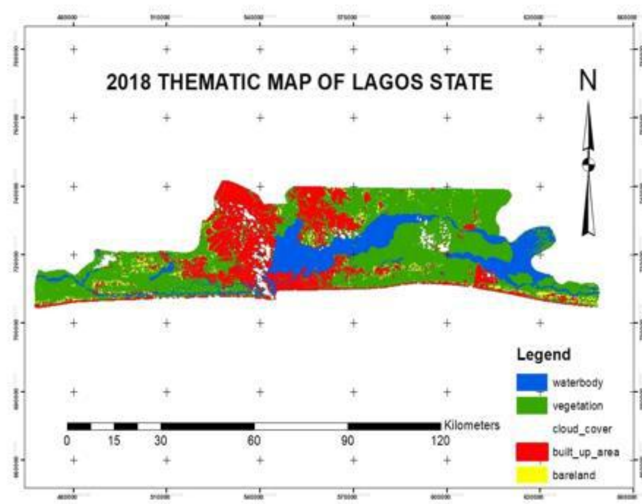

Fig.3.4: Thematic Map of 2018

These maps show a clear pattern of increased urban expansion of the town prolonging both from urban centre to adjoining non-built up areas along major transportation corridors. The maps show the spatio-temporal urban expansion pattern in the study area.

Post classification comparison of the classified images revealed the expansion pattern of the town in different directions, the infilling of the open spaces between already

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built up areas and the dynamics of urban expansion in the study area.

However, it is important to assist the findings with statistical evidences as it is useful to describe the spatial extent and the different patterns of urban expansion that have been occurring in the study area. This will help understand how the State is changing over time and to compare the various expansion patterns taking place in different periods quantitatively.

The results presented in Table 3.1 below for each classes show that the total built -up area has grown from 216.00m^2 in 1986 to 247.00m^2 in 2001 and then to 522.00m^2 in 2006 and then 655.60m^2 in 2018 respectively. This is due to the high urbanization rate in Lagos state. Other illustrations below show that there are changes in all different classes across the years.

3.2 Land use change analysis for 1986, 2001, 2006 and 2018

The total value of the area of Lagos state was obtained in square kilometer (km^2) and the statistics was used to obtain the various areas of classified features for a particular epoch under consideration. Also, the percentage change and the rate of magnitude of land use/cover expansion classes for the four epochs (1986, 2001, 2006 and 2018) were determined using equation below

$$T = \frac{K}{N} * 100$$ (Zubair, 2006)…………………

Equation 5

Where

(i) T = percentage growth/change (Trend) in land use/land cover in a particular epoch under consideration.

(ii) K = observed growth/change which is the actual area covered by a land use class in a particular epoch

(iii) N = sum of growth/changes which is total area covered by all land use/land cover classes at a particular epoch.

Magnitude of area of land use/cover change: The magnitude of land use/land cover growth/expansion is the difference in occurrence of a particular class. This was determined between 1986 and 2006, 2006 and 2016, 1986 and 2016 respectively.

Table 3.1: Shows the area covered in each of the classes

Feature Class	Area (2018)		Area (2006)		Area (2001)		Area (1986)	
	Hectares	%	Hectares	%	Hectares	%	Hectares	%
Vegetation	201	53.09	235	62.28	221	58.54	224	59.41
Built-up Area	655	17.25	522	13.81	247	6.55	216	5.72
Water Bodies	633	16.67	634	16.78	678	17.95	710	18.78
Bare soil	373	9.83	269	7.13	641	16.95	608	16.10
Cloud	119	3.15	0.00	0.00	0.00	0.00	0	0.00
TOTAL	380	100	378	100	378	100.00	378	100

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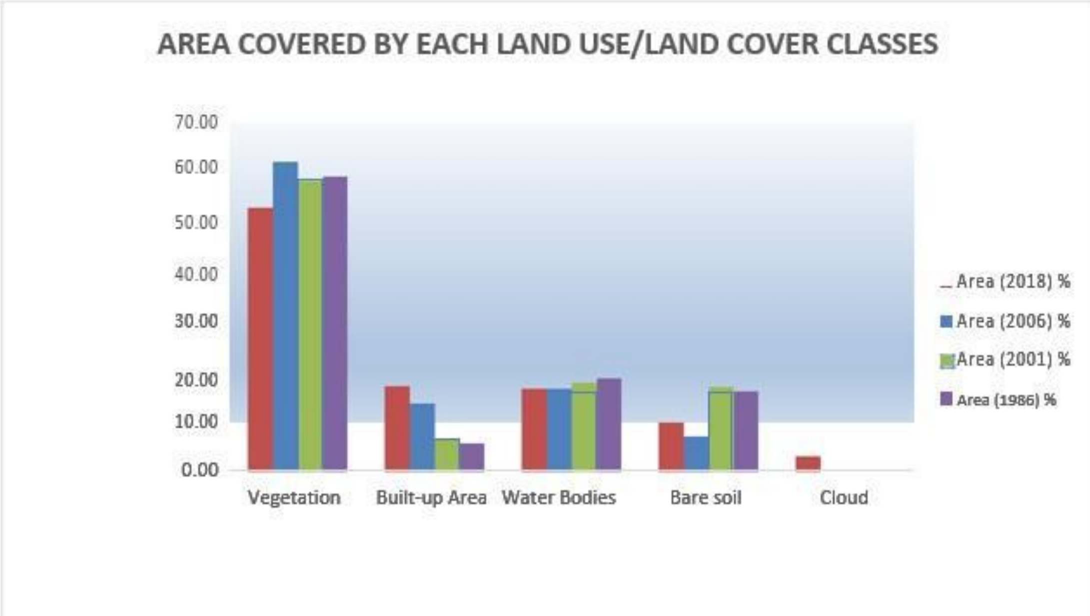

Fig.3.5: Chart showing area covered by each land use/ land cover

Table 3.2: Comparison of Area covered by each land use/ Land cover Year in SQM

CLASS	1986-2001 SQM	1986-2006 SQM	1986-2018 SQM	2001-2006 SQM	2001-2018 SQM	2006-2018 SQM
VEGETATION	-32634000.00	108730950.00	-228898125.00	141364950.00	-196264125.0	-337629075.0
BUILT_UP_AREA	31716000.00	305921475.00	439596061.60	274205475.00	407880061.60	133674586.60
WATER	-31194725.00	-75518150.00	-76502031.80	-44323425.00	-45307306.80	-983881.80
BARESOIL	32456525.00	-338920300.00	-234947700.00	-371376825.0	-267404225.0	103972600.00
CLOUD	0.00	0.00	119643750.00	0.00	119643750.00	119643750.00

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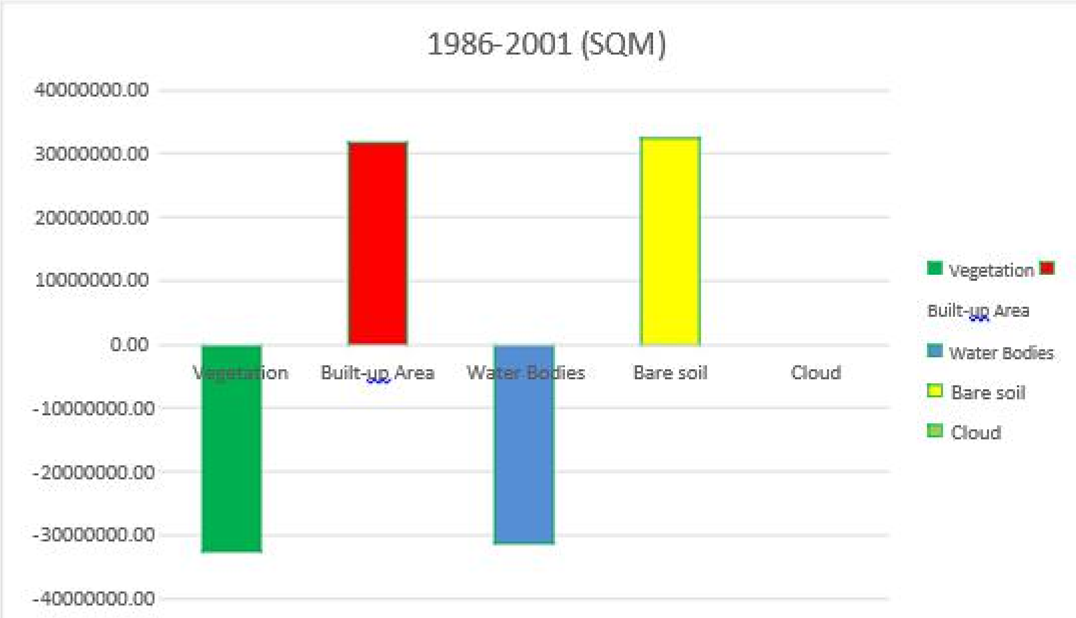

Fig.3.6: chart showing land use/cover from 1986-2001

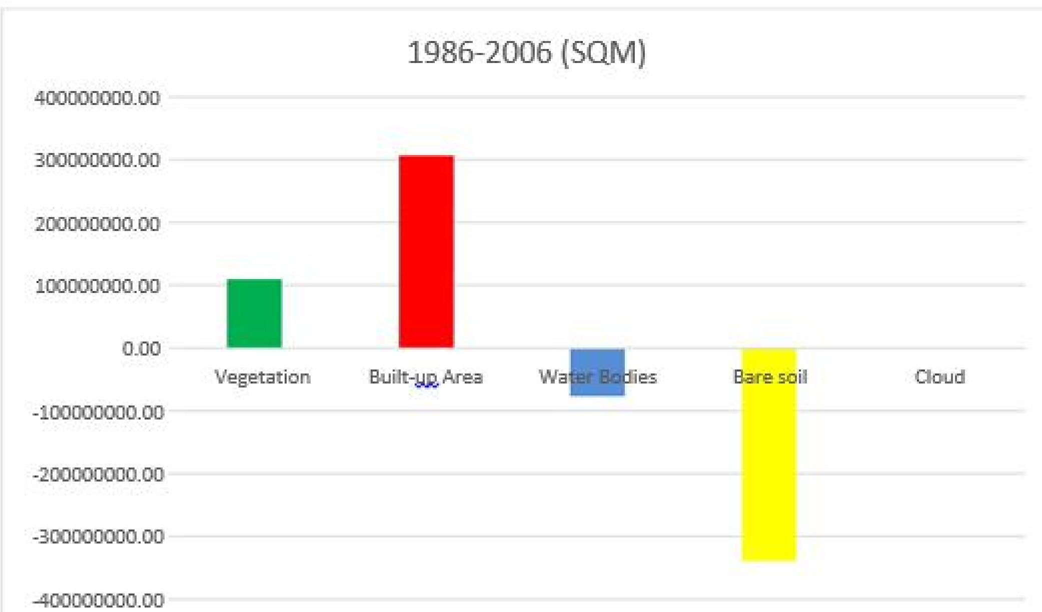

Fig.3.7: chart showing land use/cover from 1986-2006

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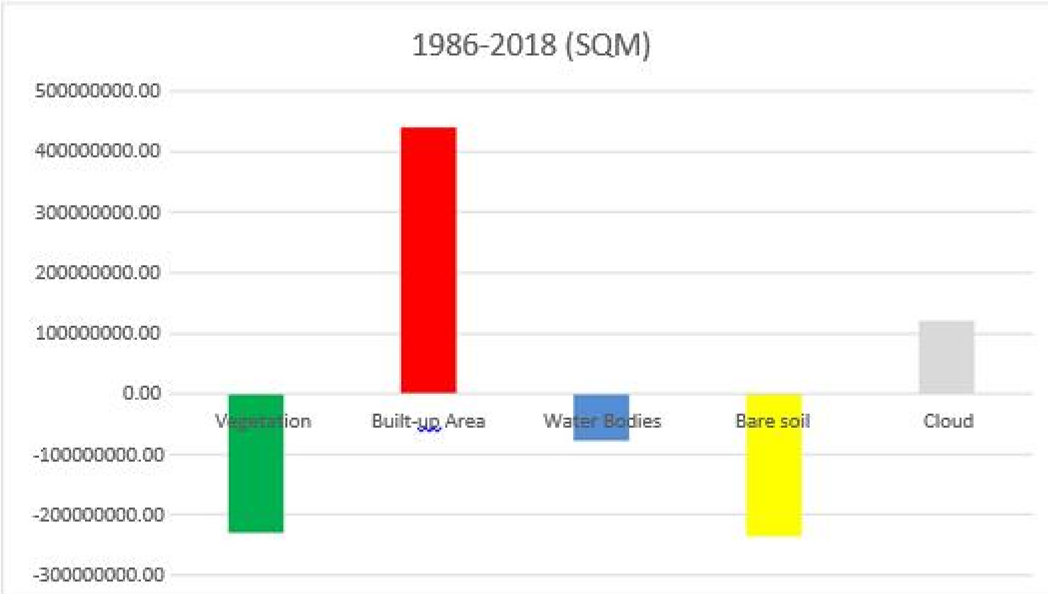

Fig.3.8: Chart showing land use/cover from 1986-2018

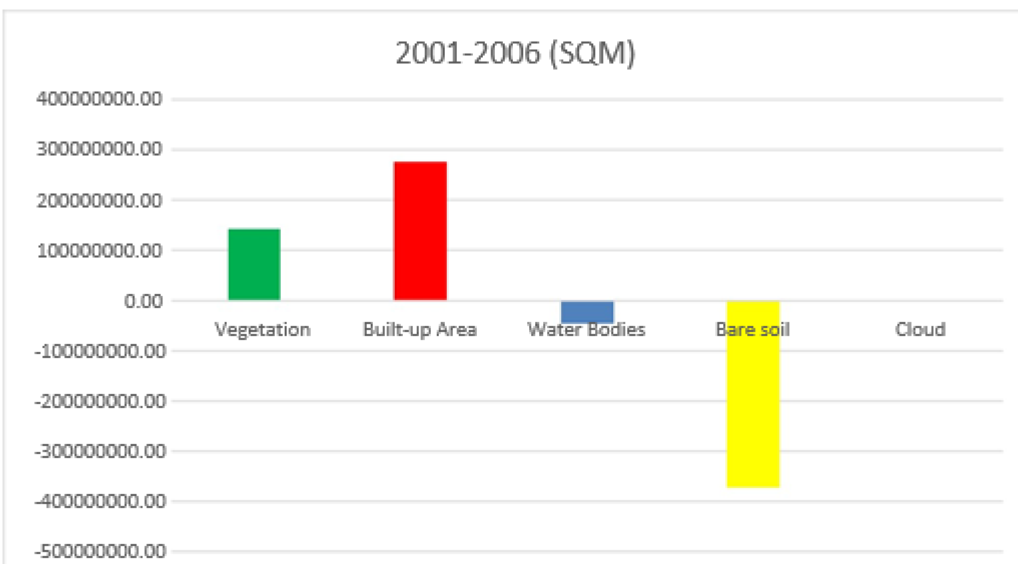

Fig.3.9: Chart showing land use/cover from 2001-2006

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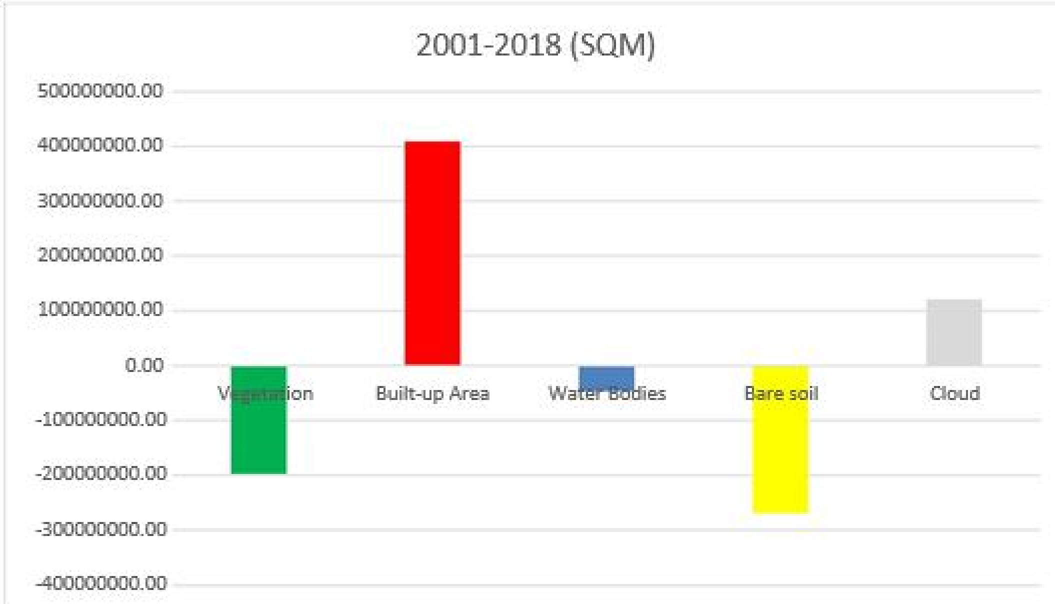

Fig.3.10: Chart showing land use/cover from 2001-2018

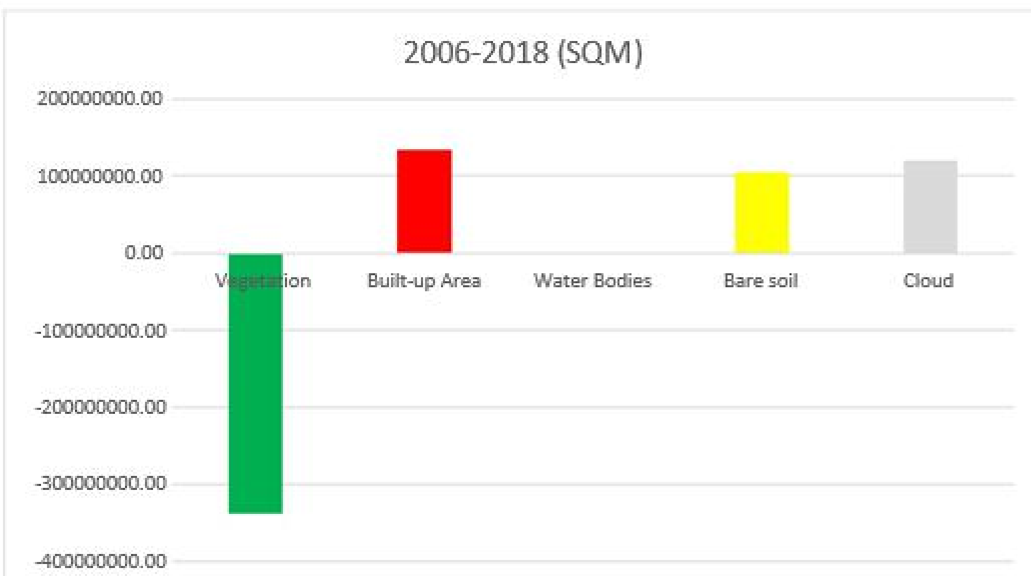

Fig.3.11: Chart showing land use/cover from 2006-2018

3.2.1 Effect of Cloud Cover

It can be seen that the 2018 map (Figure 3.4) was affected by cloud cover which affected the area of the features that were classified for that year. While comparing the classified images in each year against one another, the cloud present in 2018 didn't affect the other images. This is true because the same area of cloud in 2018 was the same that was recorded in the comparison since there was zero cloud cover

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present in the Landsat images of other years and the area of the cloud neither increased or decreased across the years.

3.2.2 Urban Growth

The highest rate of urban growth is observed during the third period of change (1986 to 2018) in which the built-up area increased more. One obvious reason is because the change between 1986-2018 has the highest number of years in between it (32 years) compared to the other 5 periods. Another reason might be based on the growing number of largely unskilled, unemployed and other migrants from the rural areas of the country into urban areas to either seek for job or to settle down in a more developed area and considering the high rate of Urbanization in Lagos state, it is only reasonable that the built-up area increases as the year progresses. According the Nigeria Population Census held in 2006, Lagos State was the second most populous country after Kano State. This could also be another reason for more rapid urbanization rate which could then lead to the increase in built-up area of Lagos State.

3.4 Projection of Changes in the Next 20 And 35 Years

This can be done by using the formula below, For the next 20 years;

$$\text{Changes} = \frac{\text{Changes between 2006 and 2018}}{\text{Time differences between 2006 and 2018}} \times \text{Time differnces between 2018 and 2038} \quad \text{.Equation (6)}$$

Area of feature in 2038 = change + Area of the feature in 2018…...................Equation (7)

Using the equation 6 and 7 above, the results shown in table 3.3 and 3.4 were computed.

Table 3.3: shows the projection for the next 20 years.

CLASS_NAME	CHANGES	AREA (2038)
VEGETATION	-562715125.00	1455038750.00
BUILT UP AREA	222790977.67	878570639.27
WATER	-1639803.00	632003165.20
BARESOIL	173287666.67	547018966.67

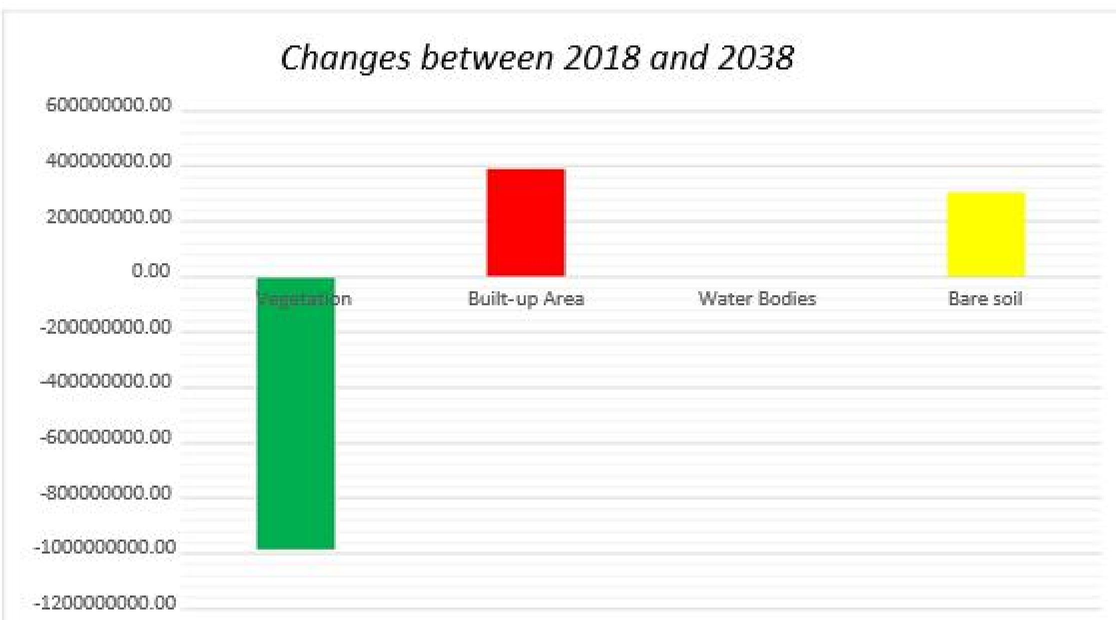

Fig.3.12: chart showing changes between 2016 and 2038

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For the next 35 years

Table 3.4: Shows the projection for the next 35 years.

CLASS_NAME	CHANGES	AREA (2053)
VEGETATION	-984751468.75	1033002406.25
BUILT UP AREA	389884210.92	1045663872.52
WATER	-2869655.25	630773312.95
BARESOIL	303253416.67	676984716.67

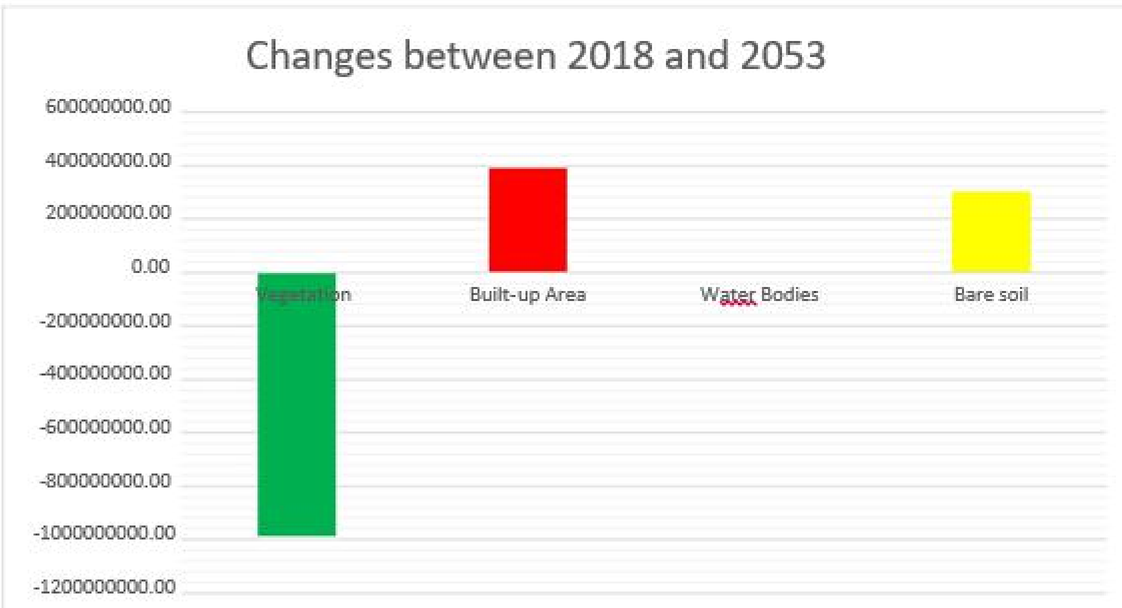

Fig.3.13: Chart showing changes between 2018 and 2053

3.5 Map Overlay

Figure 3.14 shows the expansion from 1986 to 2018 there exists drastic expansion in the spatial expansion. Due to migration, high fertility rate and low mortality rate, the population of Lagos state has been steadily growing since the last few decades exceeding the pace at which urban services and housing are provided. Also, due to these factors, the expansion of Lagos state is steadily advancing at a fast pace leading to engulfing of adjacent rural landscape and urban centres.

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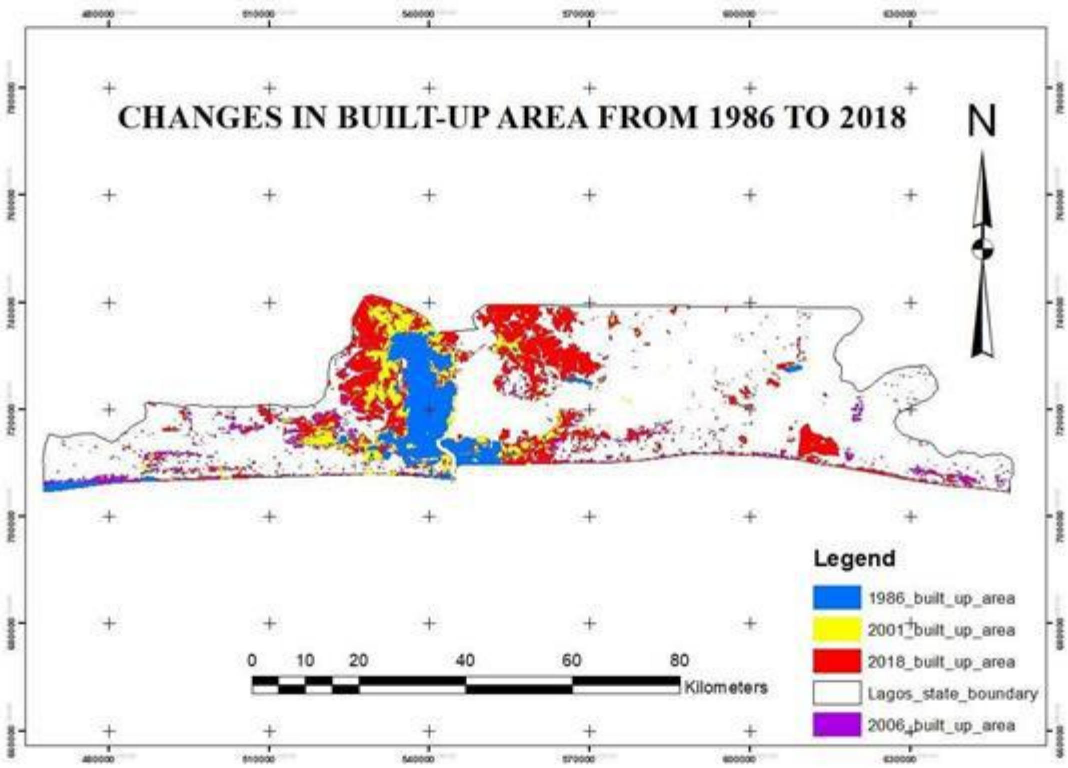

Fig.3.14: Map overlay of 1986-2018

3.6 Population Estimation and Projection for Year 1986, 2001, 2006 And 2018

According to the National Population Commission (2006), the population census for Lagos State in the year 1991 was 5,725,116 and 9,113,605 in the year 2006 with annual growth rate of 3.2%. (see table 3.5 below).

Table 3.5: shows the population for 1991 and 2006

1991	**5,725,116**
2006	**9,113,605**

Based on the aforementioned statements, the population of Lagos State was estimated for the year 1986 & 2001 and projected for the year 2018. using population value for 1991 and 2006. The population estimation and projection were done using geometric population formula (see equation 7 below).

$Pn = Po (r + 1)^n$ or $Po = Pn / (r + 1)^n$ …………………………….. Equation 8

Where Pn: (is the final or projected population for the study area)

Po: (is the initial population for the study area) =? r: (is the rate of growth for the study) and n: (difference between two years).

Using the population of 1991 to estimate for the previous year (that is, year 1986)

Firstly, the rate of growth between 1991 and 2006 is calculated by making r the subject of formula from equation 7

To estimate the population of 1986, equation 7 can be rewritten as:

P**1986** = P(**1991) /** $(r + 1)^n$

Where P**1991**: (is the final or projected population for the study area) = 5,725,116

P**1986**: (is the initial population for the study area) = ?

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r: (is the rate of growth for the study) = 3.20% and

n: (difference between two years, 1991-1986) = 5

P1986 = 5,725,116 / $(0.032 + 1)^5$ **P1986** = 5,725,116 / $(1.032)^5$

P1986= 4,890,866.45

To estimate the population of 2001, using the population of 2006;

P**2001** = P**2006 /** $(r + 1)^n$

P**2001=** 9,113,605 / $(0.032 + 1)^5$

P**2001=** 9,113,605 / $(1.032)^5$

P**2001=** 6,651,096.188

Population projection for the year 2018 using the population of 2006 to project is;

P**2018** = P**2006** $(r + 1)^n$

P**2018** = 9,113,605 $(0.032 + 1)^{12}$

P**2018** = 9,113,605 $(1.032)^{12}$

P**2018** = 13,299,844.68

Therefore, P**1986** = 4,890,866.450

P**1991** = 5,725,116.000

P**2001=** 6,651,096.188

P**2006** = 9,113,605.000

P**2018** = 13,299,844.680

Table 3.6: Shows the population estimate results across the years

POPULATION ESTIMATE RESULTS	
1986	4,890,866.450
1991	5,725,116.000
2001	6,651,096.188
2006	9,113,605.000
2018	13,299,844.680

3.7 Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC)

The LCR and LAC explain the true nature of the landscaping pattern of land use in Lagos State. There was expansion between 1986 to 2001, 2001 to 2006 and 2006 to 2018 respectively as shown in table 3.7. As the state population grows it gives room for housing, market, shopping, parking, transportation and other non -built up that come with population growth. Further expansion inland consumption is expected to occur as changes in population growth relative to the portion of land being converted from rural to urban. urban.

Table 3.7: Shows the results of LCR and LAC across the years

Year	Population Figure	Source	Built up Area (Ha)	LCR	Period	LAC
1986	4,890,866.450	Researcher's Estimate	21618.36	0.0044	1986 – 2001	0.0018
2001	6,651,096.188	Researcher‘s Estimate	24789.96	0.0037	1986 – 2006	0.0072
2006	9,113,605.000	National Population Census (NPC)	52210.51	0.0057	1986-2018	0.0052
2018	13,299,844.680	Researcher's Estimate	65577.97	0.0049	2001-2006	0.0111
					2001-2018	0.0061
					2006-2018	0.0032

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IV. CONCLUSION AND RECOMMENDATION

Multi-spectral and multi-temporal Landsat imageries and spectral indices have been able to analyze and depict the trend in land use cover changes in the area between 1986, 2001, 2006 and 2018. The following changes were observed:

- There was an increase in the built-up area between 1986 and 2018 which is largely due to the increase in population of Lagos state based on its high Urbanization rate. This is clearly manifested in the growing number of largely employed, unemployed and other migrants from the rural areas or other urban areas of the country into the Lagos state urban areas to either seek for job or to settle down in a more developed area. There is a possibility of this growth to continue based on the analysis of the changes in the next 20 and 35 years that was calculated to observe how each of the features classified would have changed overtime. Focusing on the Urban expansion, it was observed that 20 years from now, the built-up Area will have a change in area of positive 222790977.67sqm which when added to the current area would yield 878570639.27sqm.
- Vegetation cover reduced between 1986 and 2001, which is reasonable considering the rate at which the built-up area was increasing. But between 2001 and 2006, vegetation increased a little. This could have been as a result of more farming in 2006. Vegetation cover then later reduced in 2018.
- Bare land had an inconsistent change. The increase in bare land could be as result of bush burning while the reduction could be as a result of more farming in the state or development of more built-up areas.
- Also, land absorption coefficient being a measure of consumption of new urban land by each unit increase in urban population which has a consistence increment from 1986 to 2018. This therefore suggests that the rate at which new lands are acquired for development is high. This may also be the trend in 2018/2038 and 2018/2053 as concentration of development at the city center would be expanding towards the outskirts. This will make people to move away from the center of activities to the outskirts of the city.

For the past 32 years, 1986 – 2018, Lagos state has been undergoing extensive land cover change. The classification of multi-temporal satellite images of three different time periods i.e. 1986, 2001, 2006 and 2018 into built-up and non-built up land cover classes has resulted in a highly simplified and abstract representation of the study area. These maps show a clear pattern of increased urban expansion prolonging both from urban centre to adjoining non-built up areas in all directions alongside major transportation corridors.

It is recommended that Global change research efforts should be encouraged through international research partnerships to establish international land use /land cover science program to bridge the gap between climate researchers, decision makers and land managers; There was more reduction in vegetation than increase which poised a great danger that could cause greenhouse effect on the environment. Government at all levels should ensure that all these land use/land cover types are maintained to save our ecological biodiversity; As pressure is mounted on environment of development, there is continuing need for upto-date and accurate land cover information require for the production of sustainable land use policies.

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