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Land Use and Shoreline Dynamics in Lagos State, Nigeria

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ABSTRACT

The city of Lagos, Nigeria has experienced remarkable changes in terms of land use and land cover (LULC) and shoreline changes as a result of increase in population, industrialization and urbanization. These have led to coastal erosion, depletion, loss of settlement and other socio-economic problems. This contribution uses remote sensing technique to delineate coastal changes from 1999-2019 as well as LULC with a view to determine the shoreline dynamics during the study period. Landsat 7 ETM+ and Landsat 8 OLI were acquired and subjected to image pre-processing and processing techniques. The digital shoreline analysis system (DSAS) was employed to delineate the shoreline change parameters, viz: Net Shoreline Movement (NSM), End Point Rate (EPR) and Linear Regression Rate (LRR) of the shoreline for the years 1999, 2009 and 2019 respectively. The LULC result indicate that, bare-land decreases from 0.96-0.45%, vegetation decreases from 53.11-45.25% and water body decreases from 25.58-22.99%, while built-up-area increase from 20.35-31.16%. NSM values for erosion rate ranges from -36.61 to -857.46m/period, while accretion ranges from 72.72 to 260.85m/year. EPR for erosion rate ranges from -1.84 to -2.48m/year, while accretion ranges from 4.64 to 13.04m/year. LRR for erosion rate ranges from -1.83 to -2.47m/year, while accretion ranges from 3.54 to 13.04m/year. The findings revealed shoreline movement toward the sea (accretion) or movement of the shoreline inland (erosion).

1. INTRODUCTION

Change detection alludes to the identification of differences in the condition of land features by observing them at different temporal scale. This process can be achieved manually or with the guide of remote sensing techniques. (Karl and Axel, 2013). It is a process that measures how attributes of a particular location in question have changed between two or more epoch (Anusha and Bharathi, 2019).

An idealized definition of shoreline is seen as the intersection of the physical interface of land and water (Boak and Turner, 2005). On the other hand, coastal areas are locations where water is the dominant factor that encompasses or bounds it. Coastal changes caused by natural and human activities have important consequences for coastal ecosystem and coastal communities. Coastlines are natural boarders which separate water and land. Changes of coastline are of great importance, therefore, it is needed to detect these changes for economic and social purposes (Temiz and Savaş Durduran, 2016).

Coastal region of Lagos state, Nigeria is affected by considerable amount of coastal deformation caused by both natural and human activities. This study tends to examine the Land use changes and shoreline dynamics in Lagos state, Nigeria. This is with a view to detect and analyse the dynamics of the Lagos coastline over time. This study therefore, considers both the coastal and lagoon region of Lagos, as against Akinluyi et al. (2018) who only considered the coastal zone.

1.1 Study Area

Lagos state (Fig. 1) located in South-Western Nigeria. It is bounded to the North-east by Ogun state and to the West by the republic of Benin. Atlantic Ocean provides a coastline to the South. It covers an approximate area of 3907.968m^2 (Akinluyi et al., 2018).

2. DATA SOURCES AND METHOD

For the purpose of this study, satellite datasets from several sensors: Operational Land Imager (OLI), Landsat 7 Enhanced Thematic Mapper plus (ETM+) for the year 1999, 2009 and 2019 were downloaded from United States Geological Survey (USGS) through its website (http://earthexplorer.usgs.gov/) along with the

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administrative map of Nigeria (shape file format) downloaded from (diva-gis.org/datadown).

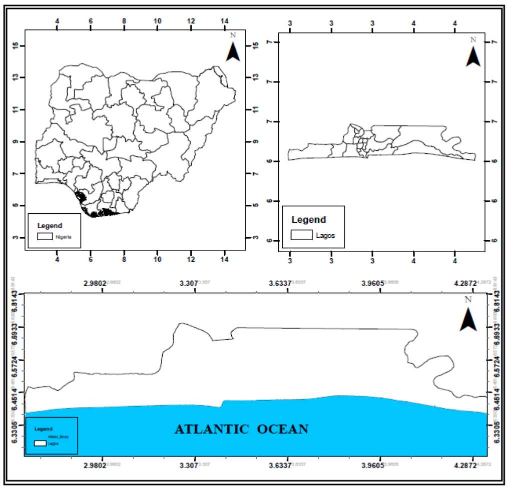

Figure 1. Map of Nigeria (top left); Lagos (top right); Lagos and South part of Atlantic Ocean (bottom)

ERDAS Imagine 9.2 was used for the pre-processing and processing of the Landsat data. While digital shoreline analysis system (DSAS)(Himmelstoss et al. 2018) was used for shoreline delineation and analysis. Fig. 2 is the summary of the workflow diagram adopted for the study. NMS, EPR and NSM are the embedded DSAS statistics used. The NSM is the distance between oldest and the youngest shorelines for each transect; EPR is the ratio of NSM by the time elapsed between the oldest and the most recent shoreline; a least-squares regression line is fitted to all shoreline points for a transect to compute the LRR.

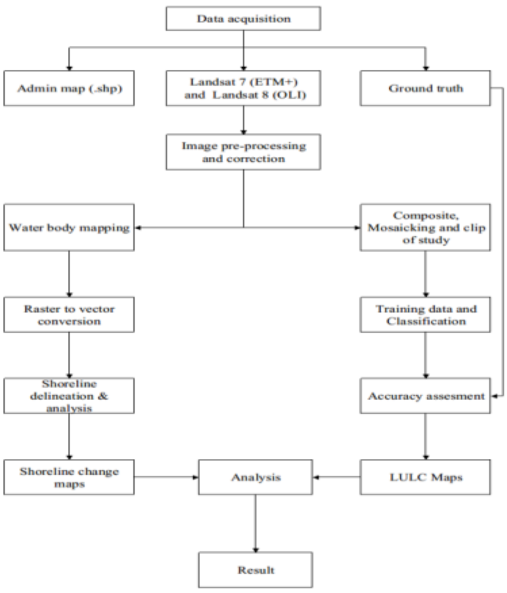

Figure 2. Workflow diagram adopted for the study

3. RESULTS

3.1. Land Use Land Cover (LULC) Distribution

The bar chat in Fig. 3 and Table 1 show the overall Land Use Land Cover change (LULC) for the duration of twenty (20) years from 1999-2019 of Lagos state. Fig. 4, 5 and 6 depict the derived LULC map of the study area for the year 1999, 2009 and 2019 respectively. However, calculated values from the classified multi-temporal satellite imageries show a remarkable change in terms of the classified classes namely: bare-land, built-up-area, vegetation and water body respectively. Base on the trend analysis, results show that bare-land; vegetation and water body experience a noticeable decrease which is as a result of urbanization. In Table 1, it is presented that, bare-land decrease from 0.96 to 0.41%. Similarly, vegetation decreases from 53.11 to 45.25% and the area covered by water body is 25.58%, 22.98% and 22.99% for years 1999, 2009 and 2019 respectively. On the other hand, built-up-area experiences a remarkable increase. The areas covered are 20.35%, 23.77% and 31.16% for the years 1999, 2009 and 2019 respectively.

Accuracy assessment was then performed by a collection of 100 random points from ancillary data and the overall accuracy, producer and user accuracy as well as the Kappa coefficient is reported in Table 2.

Table 1. Land use classes from 1999-2019

Classes	1999		2009		2019	
	Area (Ha)	Area (%)	Area (ha)	Area (%)	Area (Ha)	Area (%)
Bare-land	3643.6	0.96	1692.56	0.45	1558.34	0.41
Built-up-Area	76968.7	20.35	89881.98	23.77	118752.8	31.35
Vegetation	200844.9	53.11	199688.4	52.8	171433.4	45.25
Water Body	96741.58	25.58	86935.92	22.98	87106.25	22.99
TOTAL	**378198.8**	**100**	**378198.8**	**100**	**378850.8**	**100**

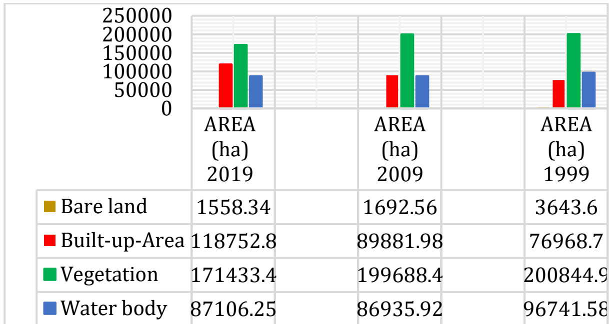

Figure 3. Land Use Land Cover (LULC) trend of Lagos from 1999-2019

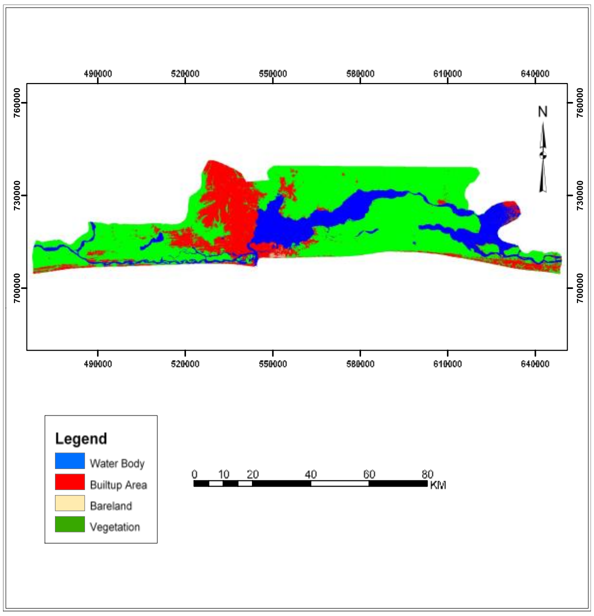

Figure 4. Derived LULC map of Lagos, Nigeria 1999

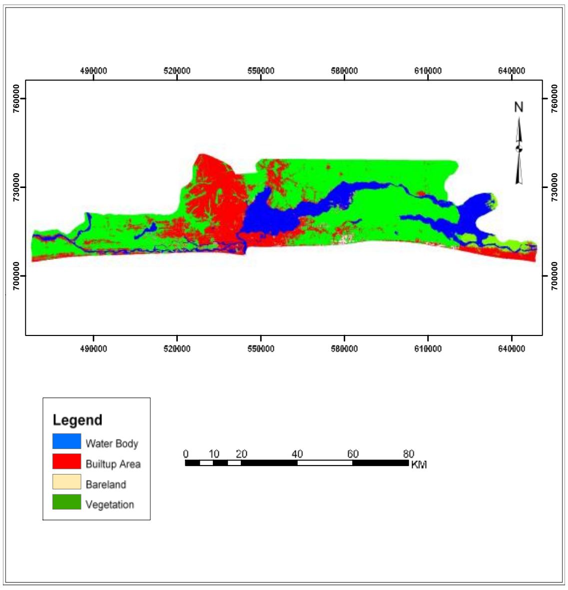

Figure 5. Derived LULC map of Lagos, Nigeria 2009.

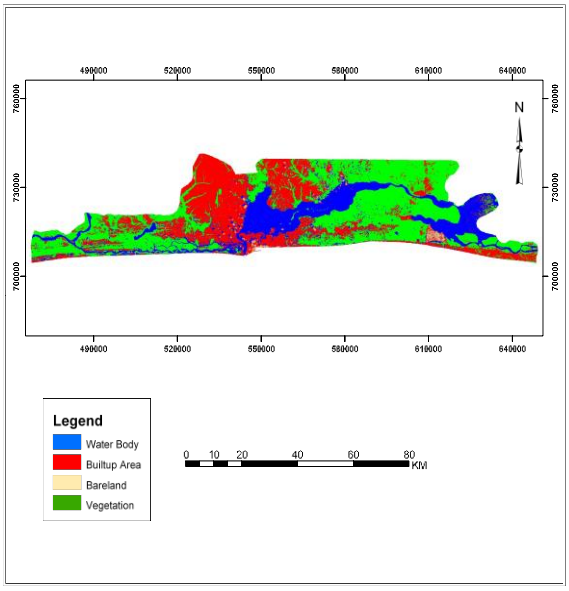

Figure 6. Derived LULC map of Lagos, Nigeria 2019.

Table 2. Accuracy result of the classified images

Classes	1999		2009		2019	
	Producer accuracy (%)	User accuracy (%)	Producer accuracy (%)	User accuracy (%)	Producer accuracy (%)	User accuracy (%)
Bare-land	95.83	92	100	92	98	96
Built-up-Area	100	96	96.15	100	100	97.83
Vegetation	96.15	100	96.15	100	100	98.24
Water Body	92.31	96	98	96	92.59	100
Kappa statistics	0.95		0.96		0.97	
Overall accuracy	96.00		97.00		97.00	

3.2. Shoreline Change Rate from 1999-2019

The total length of the extracted shoreline was computed using South Atlantic Ocean part of Lagos and lagoon as reference. The extracted shoreline length for Landsat 7 ETM+ image of the year 1999 is 186.51km, for 2009 is 187.04km, and that of the Landsat 8 OLI of the year 2019 is 188.84km respectively with reference to the open sea (South Atlantic Ocean). On the other hand, when Lagoon is considered, the extracted shoreline length for the year 1999 is 549.00km, 551.87km for 2009, and 579.02km for the year 2019 respectively. From 2009 to 2019, results show the movement of the shoreline towards the sea (accretion rate) to a distance of approximately 2 kilometres as result of the construction of Eko Atlantic city along the coast in the southern axis.

Over time, the extracted shorelines reveal that there is a remarkable change in the shoreline width (see Fig. 7 and 8). A total of over 2000 number of transects were generated with 200m spacing and averaged change rate of the shoreline was calculated from 1999-2019. Tables 3 and 4 show the result of the shoreline change statistics, positive estimations of the change insights speak to a shoreline development towards the ocean (accretion) rate and negative values speaks to a shoreline development inland (erosion) rate.

Table 3. Lagos Shoreline change rate from 1999-2019

Shoreline change statistics	Erosion	Accretion
NSM (m/period)	-36.61	260.85
EPR (m/year)	-1.84	13.04
LRR (m/year)	-1.83	13.04

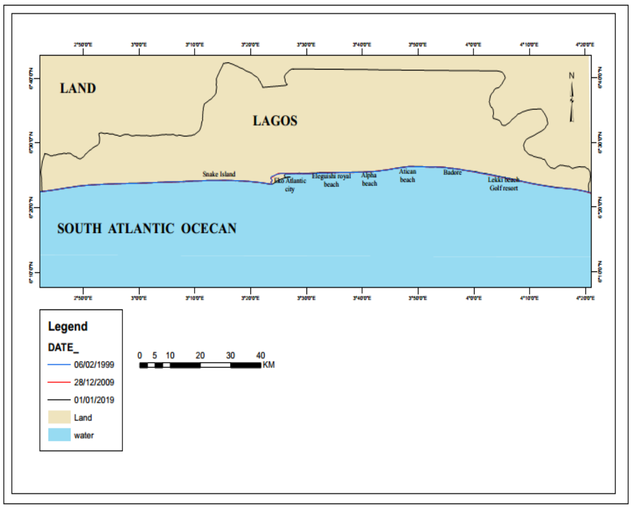

Figure 7. Shoreline change map of Lagos coastline 1999-2019

Table 4. Lagos and Lagoon Shoreline change rate from 1999-2019

Shoreline change statistics	Erosion	Accretion
NSM (m/period)	-857.46	72.72
EPR(m/year)	-2.48	4.64
LRR (m/year)	-2.47	3.54

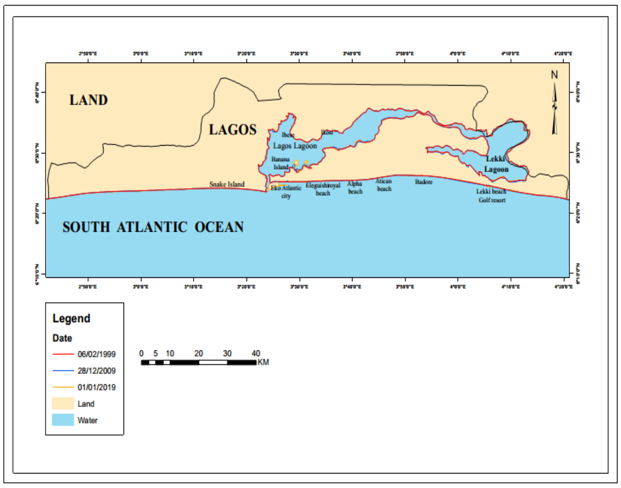

Figure 8. Shoreline change map of Lagos coastline and the lagoon 1999-2019

4. DISCUSSION

The study presents remarkable land use and shoreline changes in Lagos state Nigeria by taking advantage of multi-temporal satellite mission and state of the art geospatial software.

The dominant land use class for the study period (1999, 2009 and 2019) increasing at a very fast rate is the built-up areas (see Table 1 and Fig. 3). This is consistent with the study of (Akinluyi et al., 2018). The water body decreased by about 3.6% from 1999-2019. This might be attributed to land reclamation activities by the Lagos state government.

When only the coast line is considered, the NSM reveal that about 78.05% of the transects had negative distances while 21.95% had positive values. These values are the same for the percentage of EPR that have erosional and accretional values respectively. For the LRR, 78.02% of the transects are erosional while 21.98% are accretional. When only the coast line and Lagoon are considered, the NSM reveal that about 35.14% of the transects had negative distances while 64.86% had positive values. These values are the same for the percentage of EPR that have erosional and accretional values respectively. For the LRR, 35.16% of the transects are erosional while 64.84% are accretional.

For the first case, possible reason for high erosional rate in the coastline is a result of destruction of vegetation for residential purposes (see Figs. 4, 5 and 6). While for the second case, the effort to the authorities concerned to reclaim land might have resulted to the high percentage of accretion.

5. CONCLUSION

The contribution has illustrated the use of remote sensing technique in monitoring coastal changes in terms of Land Use Land Cover (LULC) and long term coastline geometry change study with reasonable accuracy.

The LULC classes (bare land, vegetation and water body) are migrating to build up area class. It was also observed that the coastline of the city of Lagos, Nigeria has experience a change in both position and geometry.

Based on the findings it was observed that significant changes occurred in the coastal region as a result of both natural and anthropogenic activities.

The calculated shoreline change results indicate the shoreline movement toward the sea (accretion) or movement of the shoreline inland (erosion). Therefore, the use of remote sensing and GIS technique prove to be useful in monitoring changes in the coastal region for decision making.

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