

ASSESSMENT OF THE IMPLICATIONS OF URBAN DEVELOPMENT ON THE LAGOS LAGOON

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Abstract

This study assessed the implications of urban development on Lagos lagoon through the inventorying of the static LULC pattern, assessment of the spatio-temporal changes for the period between 1984, 2000 and 2016 and investigation of the factors responsible for the observed changes. The study adopted Remote Sensing and social surveys techniques. The result of the LULC classification showed that the spatial extent of Lagos lagoon covered 392.42 km² (32.2%) of the study area in 1984. In 2000 however, this area decreased by 1.2% (14.12 km²) giving rise to an area of 378.30 km², while in 2016, a reduction of 0.6% (7.18 km²) left the spatial extent of the lagoon to 371.12 km². The total area of lagoon loss in the last 32 years was therefore 1.7% (21.30 km²). Findings from this study also showed that occupation, nearness to place of work, affordable rent and social amenities were the major factors responsible for urban development around the lagoon in order of their importance respectively. The study recommends that people around the lagoon should be educated on the importance of the lagoon ecosystem so that management of this valuable resource can be made easier in the future and in the facet of sustainability.

Key Words: Environmental issues, Land Use/ Land Cover (LULC), Lagos lagoon.

1.0 Introduction

Coastal lagoons are enclosed or semi-enclosed bodies of water that are typically oriented parallel to the coast. Found on all continents except Antarctica, they are separated from the ocean by a sand barrier and connected to the ocean by one or more inlets, which remain open permanently or intermittently (Henry , 2005). They are highly productive systems that contain many types of habitats, supporting both high biodiversity and multiple human uses, including aquaculture, fisheries, tourism and urban development.

Even though all coastal lagoons have innate differences in their geomorphology and functions, most are undergoing significant changes as a result of natural and human activities. However, Mahapatro *et al.* (2013) and Onyema (2009) claimed that stress on coastal lagoons is increasing day by day as a result of both natural and anthropogenic activities. In specific terms, building of houses, construction of road and industrialization are posing significant threats to the services these water bodies render to support human lives. Mycoo (2002) equally argued that due to their

proximity to both domestic and industrial activities especially in the highly urbanized and industrialized areas of world, lagoons are fast becoming the most vulnerable aquatic groups.

The Lagos lagoon environment is being developed in a haphazard manner; whereby structures are being erected without planning authority approval and illegal developments are condoned making development control ineffective (Aladare., 2014). This has led to the degeneration of the waterfront into slums with non-distinctive housing; mainly shanties at various points in addition to wood processing, sand dredging, markets and commercial fishing activities (Uduma, 2012).

There is also the reclamation of land achieved through filling up of swamps and floodplains, and destruction of mangroves and wetlands which have generally reduced the flood storage capacity of the urban land (Adelekan, 2009). The rapid and largely unplanned urban growth that has resulted in land use changes and subsequent changes in the hydrological fluxes in the urban watershed which has been attributed to increasing flood hazard and risk in many parts of the metropolis is also a problem (Adelekan, 2009).

The socio-economic activities taking place at the littoral areas of Lagos lagoon which encourage human congregation, also engender pollution of all descriptions (Ojelowo and Bolanle, 2011). Specifically, Iddo in Apapa Local Government and Ebute-ero in Lagos Island Local Government areas which are two principal points around the Lagoon known for high population concentration have excess organic nutrients, because raw human faeces are discharged into the lagoon without treatment. Thus, deterioration of the quality of water ensues and all signs of water pollution are obvious. The raw faecal effluent present in the lagoon is oxygen demanding, aerobic (oxygen-requiring) bacteria can only decompose it. The presence of these bacteria in large number perhaps to detoxify excreta waste degenerate the water quality by

reducing the quantity of oxygen, and therefore, leading to massive demise of aquatic animals (Ojelowo & Bolanle, 2011).

Even though, multi-disciplinary research along the coastal areas continue to support the view that the maintenance of biodiversity in coastal systems is an essential element for sustainability in the area, sustainability of coastal systems especially in developing low income countries may be difficult due to the inadequate resources for the continuous monitoring, detailed investigation and evaluation of procedure for natural resource exploitation and utilization (Junghans, 2012).

This study is therefore an attempt at ensuring the sustainability of the Lagos lagoon through the investigation, monitoring, and evaluation of the implications of urban development on the lagoon. This is through the assessment of the spatio-temporal changes for the period between 1984, 2000 and 2016 and investigation of the factors responsible for the observed changes.

2.0 Methodology

2.1 The Study Area

The Lagos Lagoon forms part of an intricate system of water ways made up of lagoons and creeks that are found along the coast line of Nigeria. It is connected to the Atlantic Ocean by Commodore Channel in Lagos. The Lagos Lagoon is land bounded to the north by Ikorodu and Epe LGAs, to the south by Lagos Island, Eti-osa and Ibeju Lekki LGAs, in the west by Shomolu and Lagos mainland LGAs and in the east by Lekki lagoon in which they are connected. Lagos lagoon is located between Latitudes 6.3667°N and 6.6333°N and Longitudes 3.3833°E and 3.6333°E (Figure 1). The lagoon is more than 50 km long and 3 to 13 km wide, separated from the Atlantic Ocean by long sand spit 2 to 5 km wide, which has swampy margins on the lagoon side. The Lagos lagoon is shallow in most places, usually less than 1.5 m deep (Obiefuna *et al.*, 2013)

and receives fresh water from important rivers like Yewa, Ogun, Ona and Osun.

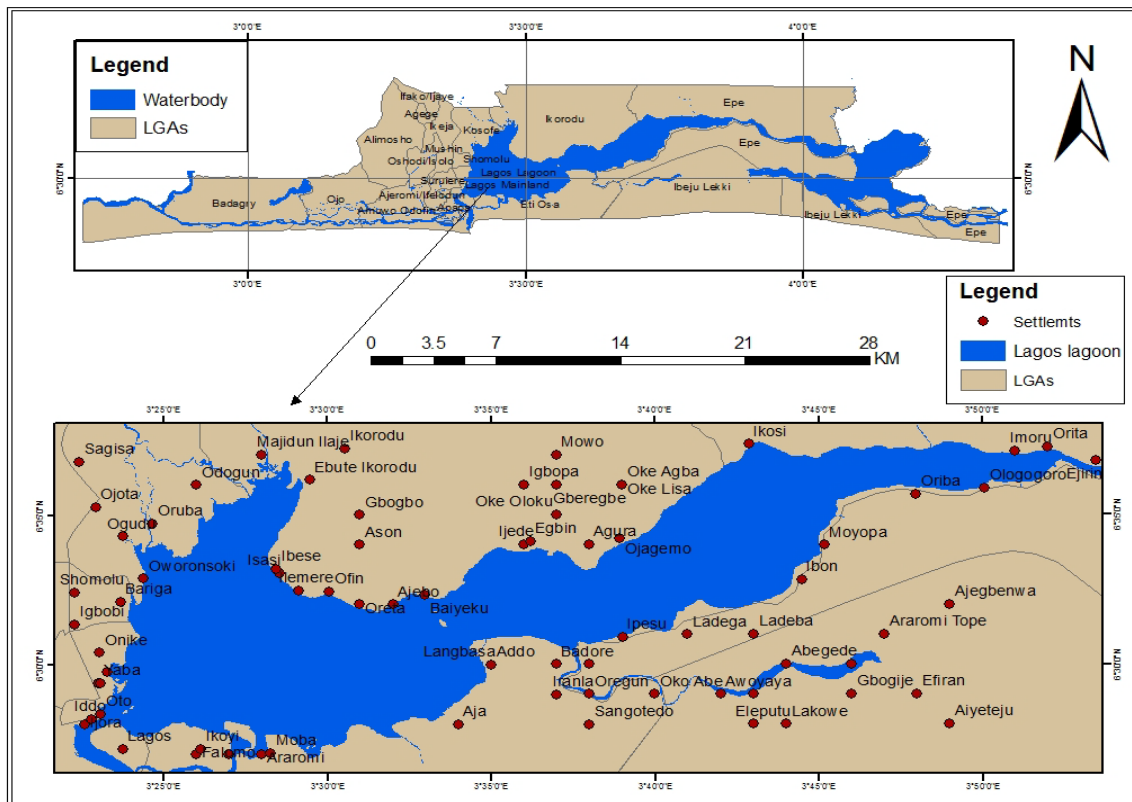


Figure 1: The Lagos Lagoon (Source: Laboratory for Cartography and Remote Sensing (LABCARS), UNILAG 2016)

2.1 Material and Methods

Data used for this research entails both spatial and non-spatial data. The sources and characteristics of spatial data used are presented in Table 1.

Table 1: Data Source and Characteristics

Data	Resolution	Source	Date	Data Usage
Landsat 5 TM	30m	USGS	1985	Inventory and Land Use Land cover classification
Landsat 7 ETM+	30m	USGS	2000	Inventory and Land Use Land cover classification
Landsat 8 OLI	30m	USGS	2015	Inventory and Land Use Land cover classification
Questionnaire		Field work	2016	Impacts of urban development on the lagoon

2.2 Data Pre-Processing, Processing and Interpretation

Remote sensing and GIS techniques were used to interpret and classify the satellite images (Table 1) in order to generate the spatial characteristics of LULC for 1984, 2000 and 2016. The first step taken was the inspection and examination of the Landsat images with respect to resolutions and the minimum mapping unit (MMU) in order to determine the bands that are suitable for the analysis. Consequent upon this, Landsat TM, ETM+ and OLI bands 7, 5, 3 were used to generate the false colour composite images for 1984, 2000

and 2016. A systematic image classification scheme was adapted from Anderson et al (1976). Thus, seven classes were generated as presented in Table 2. Training data, which correlates with the number of classes were generated and delineated. Signature files were also developed using the ENVI software. Subsequently, the maximum likelihood classifier was used to classify the images to generate the base maps and inventories of LULC for 1984, 2000 and 2016.

Table 2: Land Use Land Cover Level I Classification

Code	Land Use Land Cover	Mapping Unit Description
1	Built Up Area	All residential, commercial and industrial areas, transportation, infrastructure and institutions
2	Waterbody	Lagoon, river, lake, open water
3	Wetland	Coastal wetland
4	Farmland	Agricultural land
5	Forest	Trees capable of producing timber or other wood products, and exert an influence on the climate or water regime.
6	Grassland	Grasses, grass like plants, forbs, or shrubs
7	Bare Surface	Earth and sand fillings, construction sites, open space, solid waste landfills and exposed soil.

The method adopted for change analysis is the one sequel to Lu, et al. (2004) which asserts that good change detection must take cognizance of the following points; (1) area change and change rate; (2) spatial distribution of changed types; (3) change trajectories of land-cover types; and (4) accuracy assessment of change detection results. The post-classification method is well implemented in the ENVI software. Firstly, it was ensured that the base maps of 1984, 2000 and 2016 had the same spatial extents; that the number of columns and rows were equal and were then combined (i.e. 1984, 2000 and 2016) to generate maps for the periods. In conclusion, the change analysis was carried

out by comparing the area covered by each of the LULC classes and so matrix tables were generated with validation of final results.

The investigation of the factors responsible for urban development around Lagos lagoon was achieved by the use of questionnaires. The questionnaire is divided into three section. Through the systematic stratified random sampling method, questionnaires were distributed randomly to one community in each of the 8 (eight) LGAs bounded by the Lagos lagoon. However, 20 questionnaires each were distributed only to 6 (six) communities out of the 8 (eight) in each LGAs that bounds the lagoon. Therefore, a total of 120 questionnaires were distributed

and 100 was retrieved after the completion of the exercise. Administering of questionnaire started from Bayieku in Ikorodu LGA to other communities such as Ilaje in Shomolu LGA, Oworonshoki in Kosofe LGA, Makoko in Lagos mainland LGA, Badore in Eti-Osa LGA and Ejirin in Epe LGA.

3.0 Result and Discussion

3.1 LULC pattern around Lagos Lagoon for 1984, 2000 and 2016

The static characteristics of LULC pattern within the study area are as shown in Table 3 and Figure 2. The waterbody (lagoon) had a spatial extent of 392.42 km^2 , which is 32.2% of the total extent of the study area in 1984. In addition, wetland and built up area occupied

about 115.78 km^2 (9.5%) and 80.29 km^2 (6.6%) respectively. Other LULC classes include farmland, forest and bare surface which covered an area of 48.48 km^2 (4.0%), 279.87 km^2 (22.9%) and 16.20 km^2 (1.3%) respectively, while grassland occupied about 151.36 km^2 (12.4%). Cloud cover was however discovered to cover about 135.79 km^2 (11.1%) of the total study area in 1984. With respect to the LULC in 2000 (Figure 2b), the spatial extent of waterbody (lagoon) was 378.3 km^2 which was about 31% of the total study area. Wetland and built up area occupied about 127.47 km^2 (10.4%) and 202.79 km^2 (16.6%) respectively. The remaining area was covered by grassland with about 329.71 km^2

Table 3: 1984, 2000 and 2016 static LULC Pattern Inventory

S/N	LULC Class	Area km^2 (1984)	%	Area km^2 (2000)	%	Area km^2 (2016)	%
1	Water body	392.42	32.2	378.3	31	371.12	30.4
2	Bare Surface	16.2	1.3	4.33	0.4	25.38	2.1
3	Wetland	115.78	9.5	127.47	10.4	109.31	9
4	Built Up Area	80.29	6.6	202.79	16.6	342.85	28.1
5	Farmland	48.48	4	0.76	0.1	0	0
6	Forest	279.87	22.9	176.82	14.5	103.97	8.5
7	Grassland	151.36	12.4	329.71	27	267.54	21.9
8	Cloud cover	135.79	11.1	0	0	0	0
	Total	1,220.18	100	1,220.18	100	1,220.18	100

Source: GIS Analysis of Interpreted Remotely Sensed data (2016)

(27.0%), forest which occupied about 176.82 km^2 (14.5%) and farmland with a spatial extent of about 0.76 km^2 (0.1%). The LULC for 2016 (Figure 2c) on its part revealed that waterbody (lagoon) occupied 371.12 km^2 which amounted to 30.4% of the total study area of 1220.18 km^2 . Also, wetland and built

up area occupied about 109.31 km^2 (9.0%) and 342.85 km^2 (28.1%) respectively. Other LULC covered an area of 103.97 km^2 and 267.54 km^2 forest and grassland respectively, and accounted for about 8.5% and 2.1% of the total study area.

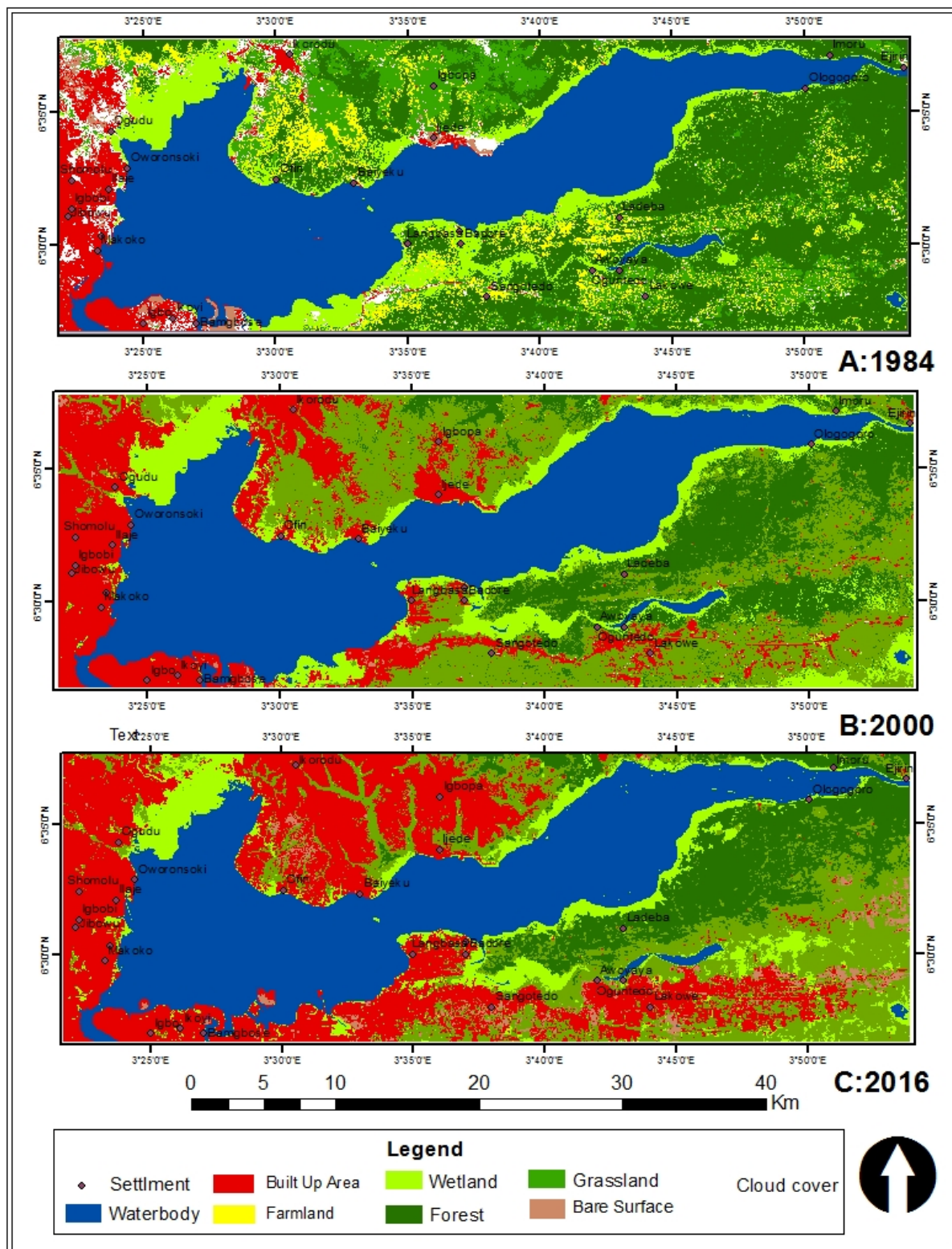


Figure 2: Static LULC Pattern of 1984, 2000 and 2016

3.2 Spatio-temporal Characteristics of the Land Use Land Cover (1984-2016)

The magnitude and nature of change in the static and temporal characteristics of waterbody (lagoon), wetland, built up area and other land cover within the study area are shown in Figure 3.

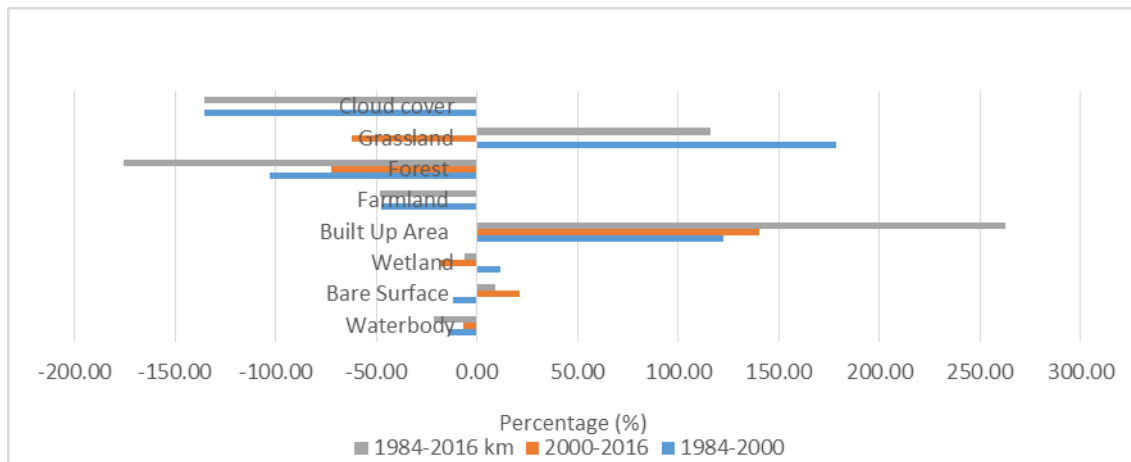


Figure 3: Net Changes in the Land Use Land Cover (1984-2016)

The study reveals that waterbody lost about 1.2% (14.12 km^2) from 392.42 km^2 to 378.30 km^2 between 1984 and 2000, while built up area and wetland gained about 10.0% (122.49 km^2) and 1.0% (11.70 km^2) within the same period respectively. Also, forest, farmland and bare surface lost about 8.4% (103.05 km^2), 3.9% (47.71 km^2) and 1.0% (11.87 km^2) as shown in Figure 3. Moreover, waterbody (lagoon), forest, grassland, bare surface and wetland lost 1.7% (21.30 km^2), 14.4% (175.90 km^2), 9.5% (116.18 km^2), 0.8% (9.19 km^2) and 0.5% (6.47 km^2) from 1984 to 2016 respectively. However, built up area increased with 21.5% (262.56 km^2) between 1984 and 2016. This generally shows that waterbody (lagoon) and wetland has decreased, while built up area and bare

surface has increased over the 32-year study period.

Nevertheless, it was discovered that between 1984 and 2016, waterbody (lagoon) lost a total of 5.44% (21.34 km^2) to built up area (18.39 km^2), wetland (2.03 km^2) and bare surface (0.92 km^2). Wetland also lost about 54.43% (63.02 km^2) of its initial area in 1984 to grassland, built up area and bare surface which amounts to 37.82 km^2 , 23.87 km^2 and 1.33 km^2 in 2016 respectively. While built up area also gained to its initial area in 1984 from wetland (23.87 km^2), waterbody (lagoon) (18.39 km^2) and bare surface (14.19 km^2) in 2016. It also gained 94.20 km^2 , 46.11 km^2 , 39.36 km^2 , and 27.655 km^2 from grassland, forest, farmland, and cloud cover respectively as shown in Table 4.

Table 4: The Land Use Land Cover Change Matrix, 1984 and 2016

		2016										
		Water body	Bare Surface	Wetland	Built Up Area	Farmland	Forest	Grassland	Cloud cover	Class Total	Loss (1984)	%Loss
1984	Waterbody	371	0.9	2	18	0	0	0	0	392	21	5.4
	Bare Surface	0	1.2	0.3	14	0	0	0.6	0	16	15	93
	Wetland	0	1.3	53	24	0	0	38	0	116	63	54
	Built Up Area	0	0.1	1.2	79	0	0	0	0	80	1.2	1.5
	Farmland	0	6.2	2.9	39	0	0	0	0	48	48	100
	Forest	0	10	42	46	0	14	168	0	280	266	95
	Grassland	0	5.7	1.2	94	0	0	50	0	151	101	67
	Cloud cover	0	0	6.9	28	0	90	11	0	136	136	100
	Class Total	371	25	109	343	0	104	268	0	1,220	652	
	Gain (2016)	0	24	57	264	0	90	217	0	652		
	%Gain	0	95	52	77	0	87	81	0			

3.3 Factors Responsible for Urban Development around Lagos Lagoon

The mean frequency of each factor responsible for urban development around Lagos lagoon ranges between 1.88 and 7.15 as shown in Table 5.

Table 5: Factors Responsible for Urban Development

	N	Minimum	Maximum	Mean	Std. Deviation
Affordable rent	100	1	7	2.83	1.341
Social Amenities	100	1	7	3.89	1.270
Occupation	100	1	5	1.88	1.076
Inheritance	100	1	8	7.15	2.285
Nature of environment	100	3	8	5.37	.861
Security	100	5	8	6.39	.790
Nearness to place of work	100	1	7	2.63	1.143
Place of Birth	100	1	8	5.85	1.743

Based on the fact that the lower the mean value, the more important the factors and vice-versa, occupation, nearness to place of work, affordable rent and social amenities are the major factors responsible for urban development around the lagoon with 1.88, 2.63, 2.83 and 3.89 as the mean values and 1.076, 1.143, 1.341 and 1.270 as the standard deviation in order of their importance respectively, while nature of environment,

place of birth, security and inheritance are the minor factors responsible for urban development around Lagos lagoon, with 5.85, 6.37, 6.39 and 7.15 as the mean values and .861, 1.743, .790 and 2.285 as the standard deviation respectively. Therefore, the loss from the waterbody (lagoon) and wetland to built-up area as investigated in Table 4 can be attributed to occupation, nearness to place of work, affordable rent and social amenities.

3.4 Impact of Urban Development on Lagos lagoon

With respect to the impact of urban development around the Lagos lagoon, the study revealed that the major impact of urban development on the lagoon is sand filling of wetland and lagoon for building purposes which is attributed to the fact that 77% of the

respondents' building are as a result of sand filling as shown in Figure 4. Also, the rate of urban development around the lagoon was stated to be rapid by 57%, not very rapid by 26%, very rapid by 11% and not rapid by 6% of the respondents.

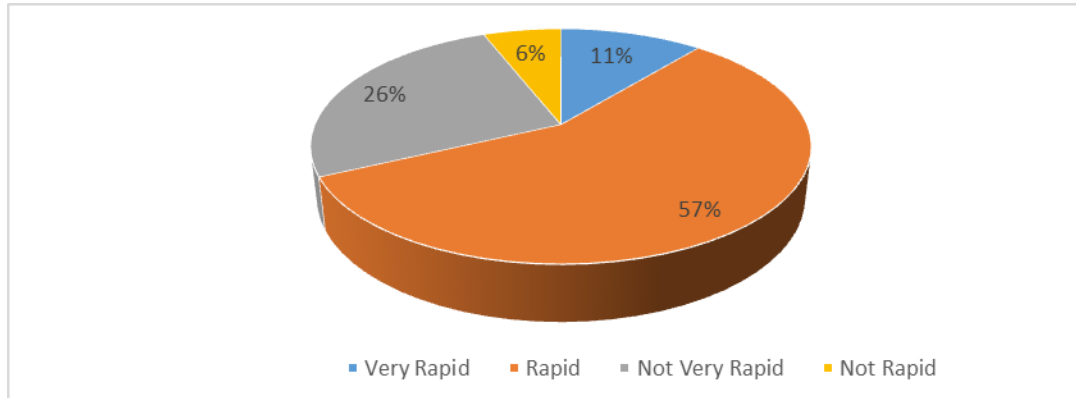


Figure 4: Rate of Urban Development around Lagos Lagoon

4.0 Conclusion

This study has been able to assess the implications of urban development on Lagos lagoon using two techniques (Remote sensing and social surveys). Specifically, Landsat TM, ETM+ and OLI images were used to discriminate the lagoon (waterbody) and built up area (urban area) from other LULC categories and to assess changes in the spatial extent of the lagoon ecosystem over a 32year (1984-2016) period. Results from the satellite-based analysis showed that the total spatial extent of lagoon changed from 392.42 km^2 to 371.12 km^2 indicating a total loss of about 21.30 km^2 over the study period. Social survey confirmed that these losses were primarily due to urbanization, and the factors that influences urban development around the study area were discovered to be occupation, nearness to place of work, affordable rent and social amenities as the major factors in order

of their preference respectively. Also, the impacts of urban development around the lagoon were deduced through the social survey to be decrease in the quantity of ecosystem services derived from the lagoon and an increase in the distance to derive the ecosystem services as well as the pollution of the lagoon as a result of waste disposed on the lagoon. These impacts were as a result of sand filling, over exploitation of ecosystem services and pollution induced by human. Clearly, the area of Lagos lagoon loss determined in this study is such that the functioning of ecological, social and economic systems within the region could be adversely affected. Hence government is advised to facilitate research and enlightenment to the populous on the importance of the lagoon and its environment.

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