Analele Universităţii din Oradea, Seria Geografie Year **XXVI**, no. **2/2016** (December), pp. **188-200**
ISSN **1221-1273**, E-ISSN **2065-3409** Article no. **262109-715**

SEA LEVEL RISE AND ITS POTENTIAL IMPACTS ON COASTAL URBAN AREA: A CASE OF ETI-OSA, NIGERIA

Ayodele Michael AGBOOLA
Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria,
e-mail: ayodelemichaelagboola@gmail.com

Ayansina AYANLADE*
Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria,
e-mail: aayanlade@oauife.edu.ng

Abstract: This study examines the spatial extent of coastal urban development and its potential sensitivity to sea-level rise. The main aim of the study is to critically examine the extent of growth in Eti-Osa over time, and the potential impacts of sea leve rise. Landsat Enhanced Thematic Mapper Plus (ETM+) imageries of years 2000 and 2015 were used to evaluate the different land use type identified. Post-classification change detection method was used to evaluate the output of the maximum likelihood supervised classification analysis done. This was also used to estimate the changes induces through urban development on the environment which accounts for the biodiversity loss. ASTER GDEM 2 imagery of 2011 was used to generate the elevation data used for the inundation analysis. Thus, both Land use map of Eti-Osa in 2015 and the down scaled Sea-level rise scenarios (at 0.5 to 15 meters) were used for the inundation mapping. Results obtained from this research affirms that indeed Eti-Osa has been subjected to gross urban expansion giving room for diverse forms of environmental degradation among which are huge replacement of natural land cover with built-up, reclamation of wetlands and sand filling of water bodies. This basically illustrates growth but also the risk that accompanies the advent of excessive alteration of natural ecosystem as Sea-level rise projections imply in this research.

Key words: Sea-level rise, Urban Development, impacts assessment,

* * * * * *

INTRODUCTION

Sea-level rise poses a major threat to most lands along the coast and also major developments having direct access to the shoreline especially in cities and other forms of development within the low-lying area around the coast (McGranahan et al, 2007). This is evident by the forecast concerning Global Mean Sea-level Rise by Intergovernmental Panel for Climate Change (IPCC, 2007), there is a projection that by the year 2020, about 75 to 250 million people would encounter the challenge of increased water (flooding) through climate change. A rise in sea-level usually increase the flooding depth and extend the area that stays wet in the dry season (Brammer, 2013). Furthermore, according to the climate change report by IPCC (2007), towards

* Corresponding Author

the end of the 21st century, the low-lying coastal areas with large population would face the challenge of Sea-level Rise and it would cost between 5-10% of Gross Domestic Product (GDP) for adaptation (IPCC, 2007). Studies have reported that the situation will be aggravated by the high rate of land subsidence (Syvitski et al., 2009), and rapid rate of coastal erosion (Vidal, 2013a, b). As peculiar to Lagos metropolis, Nwokoro and Dekolo (2012) examined that 1.31% of the total water body in Lagos within the period of study has been lost to the collective effort of continuous land reclamation and sand filling of wetland to cater for the need for residential development either by the government or private developers. These findings summed up together to imply that the urban dwellers settled along the coast and developments might be helpless against rise in sea-level. The vulnerability of the Lagos coastline to Sea-level Rise is particularly exacerbated by its low-lying, densely populated nature, a high concentration of GDP generating industries and infrastructures especially along the barrier lagoon Coast of Lagos-Badagry-Seme border of the southwestern part of Nigeria (Odunuga et al., 2014).

Urban centers experience huge rate of urban expansion as a result of diverse factors among which are population growth and human desires (Adesoji, 2011). The observed rate of urbanization comes with enormous physical developments such that the interaction between urban developments and natural state of the environment has gone far beyond equilibrium (Bai, 2001). The growing trend of urbanization in the society has induced a high degree of depletion on the environment thus, the present level of degradation of the environment (Odewaye, 2009). Lagos state has been a typical urban center to experience rapid urban development in a bit to cater for the pressing need for housing facilities and other infrastructures to support adequate livelihood conditions. The ever-increasing demand for physical developments has therefore resulted in both coordinated and uncoordinated developments leading to little or no consideration for physical planning standards. There is, therefore, intense intrusion into the natural habitat which is supposed to be conserved to aid a balance in the ecosystem (Oduwaye, 2009; Ogundele et al., 2011). As a result of the economic influence of the coastal cities as in the case of Eti-Osa in Lagos, it aids coastal population and commercial activities which are projected to also increase (Jongman et al., 2012). Hence, there has been a lot of challenges from hazardous human activities such as excessive exploitation of natural resources, biodiversity loss, depletion of natural habitat and coastal erosion (Arthurton et al., 2006; Diop et al., 2011). Consequently, coastal urban planning is faced with the challenge of adequately putting land into use to meet the demand for urban growth, equity and sustainability even at the expense of the limited nature of the habitable land. The critical concern is the inability of the concerned institutes to keep up with the pace of urban expansion and densification. The nature and potential vulnerability of coastal urban centers to inundation as an effort of Sea-level Rise (SLR) are considered as one of the measures for environmental degradation.

The projected Sea-level Rise and climate change are a pressure that should enhance the speedy preparation for national planning that would be implemented to safeguard, maintain and accelerate economic and social development in the country so as to meet the corresponding growing population and its vulnerability to existing environmental hazards (Brammer, 2010). Hence, sustainable adaptation requires institutions that can negotiate and address the demands made of an ever-changing landscape in ways that are just and legitimate, so that the institutions of planning, as well as communities at risk, are able to persist over time. Successful adaptation must therefore, be sustainable, both in terms of its ability to ensure *"socially and environmentally sustainable development pathways, including both social justice and environmental integrity"* (Reiksen et al., 2011).

A number of modeling approaches that have been used to evaluate the potential impact of sea-level rise have been critically appraised. This has availed a number of limitations and challenges such as coarse resolution levels for landscape-scale models and low confidence in site-specific model simulations. Thus, Elevation-based analysis is however identified to be of high effectiveness (Bo et al., 2010) owing to the fact that it has a very simple procedure and is effective if the appropriate data and maps are put to use in the assessment of the possible effect of inundation resulting from proposed Sea-level Rise (CCSP, 2009). The elevation-based analysis in this study entails the generation of digital elevation model (DEM), adoption of sea-level scenarios, and performing inundation spatial analysis.

STUDY AREA

Lagos is the second fastest growing coastal urban community in Africa which is economically buoyant such that urban growth and development experiences a surge within a short time. Eti-Osa, the study area is thus a prominent division of Lagos that experiences a relatively large communal expansion and hub of most large structured commercial functions of Lagos as a result of its proximity to the coast (Atlantic Ocean). The Study area lies approximately between 60 26' 20" N to 60 27' 50" N and longitudes 30 24' 10" E to 30 40' 10" E (figure 1) which covers about 180.54 km2 in land area. In Eti-Osa, a tropical climate is observed with a varying wet and dry season such with an average temperature of 28 oC annually. The wet (rainy) season has been observed to have two peaks usually May to July and September to October. As a result of diverse urban developments, several natural patterns have mostly been altered as such that land reclamation from the sea has added to the total land area. Furthermore, Eti-Osa stretches from Magrigo canal at Obalende through into Lagos lagoon and crosses the lagoon to the back of Sabokoji Island behind the port at Amuwo Odofin. Eti-Osa shares a boundary with 3 local governments namely Lagos Island local, Amuwo Odofin and Apapa.

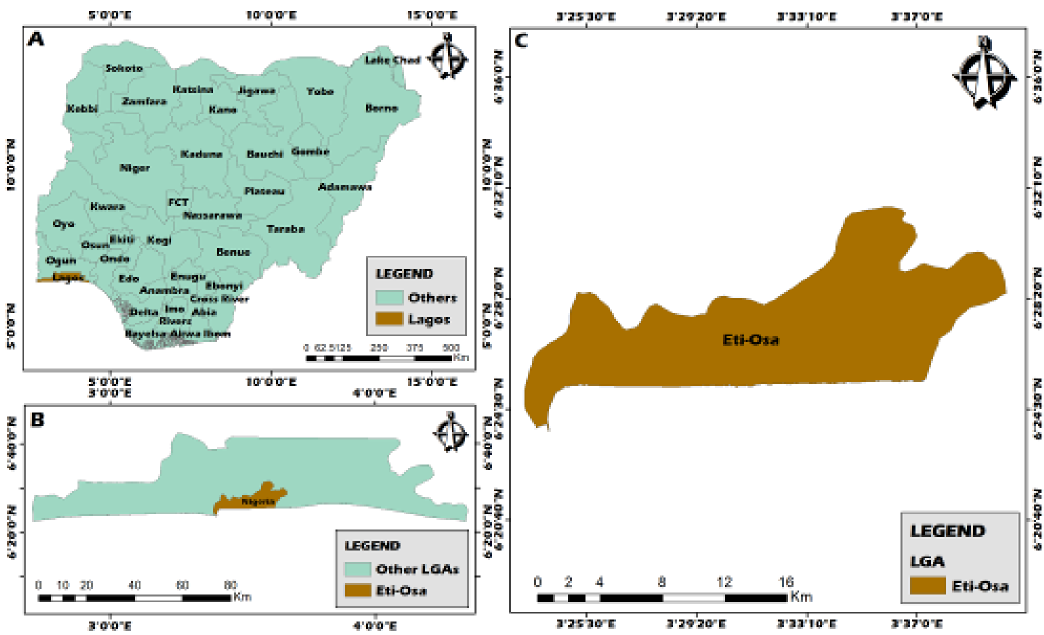

Figure 1. Maps of the study area: Nigeria (A), Lagos State (B) and Eti-Osa (C)

METHOD

Data Preparation and pre-processing

Landsat ETM+ (2000) and OLI (2015) images of Eti-Osa were acquired from the United State Geological Survey archive and are said to have been prepared in WGS 1984 (UTM Zone 31) coordinate system. This is considered most suitable for all processing and analytical functions in this study, thus image registration and atmospheric corrections were not done again. The ASTER GDEM 2 satellite imagery which was used to generate the digital elevation model and Landsat imageries acquired were both subset to extract the region of interest. This was to extract the study area using the administrative boundary information (Shape-file). The Landsat imageries, Colour compositions were done to enhance adequate visual interpretation in the analysis.

Classification scheme and Land use change

Adopting Landsat imageries of Eti-Osa in the year 2000 and 2015, a spatio temporal analysis was performed to examine the land use change over time. This was approached generating training samples representative of the identified class of land use in this study. The classes identified were *"Water body"*, *"Riparian Forest"*, *"Forest/Grassland"*, *"Built-up area"* and *"Bare land"* all to assess the rate of urban growth and identify its pattern of change over the observed time window. Maximum likelihood technique of classification was used and Post classification method of change detection was used to evaluate the percentage change of the examined land use classes because of its ability to provide information as to change and change matrix (Masroor et al., 2013).

Generation of Elevation data and Inundation Mapping (Spatial analysis)

The ASTER Global Digital Elevation Model 2 (2011) imagery was used to prepare a digital elevation model of Eti-Osa to avail the land terrain information since the topographic and land terrain data were not readily available. This ASTER GDEM imagery using Global Mapper software platform was used to generate contour lines (from terrain grid) which were used as the elevation data. This was to aid further processing in the analysis and get an adequate overview of the land terrain information of Eti-Osa as shown in figure 2. The elevation data was prepared in WGS 1984 (UTM Zone 31) coordinate system, thus there was no need for transformation.

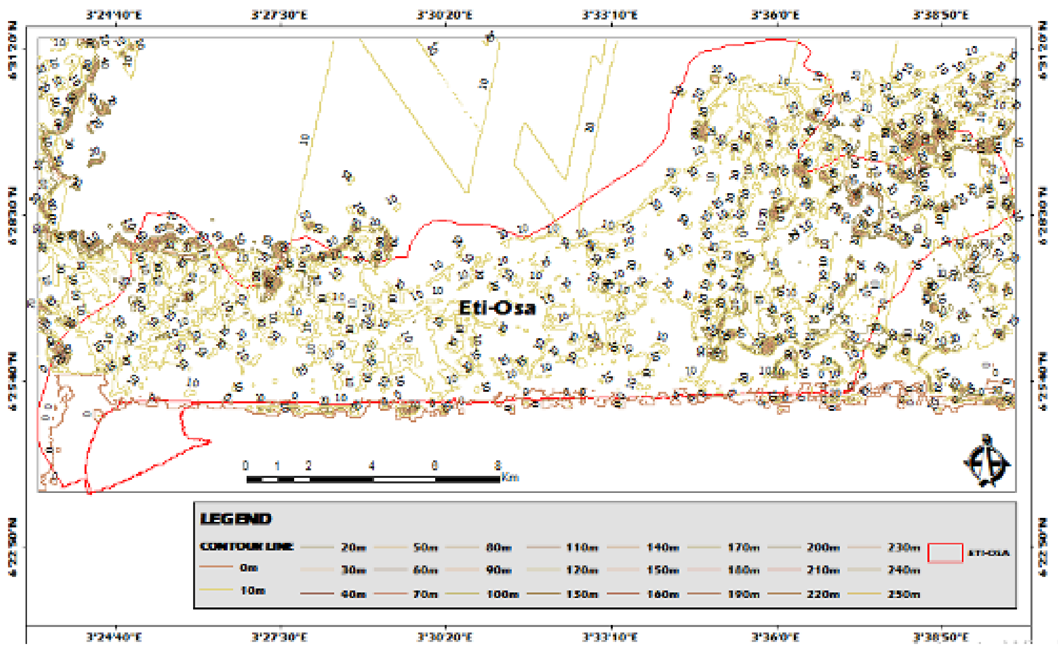

Figure 2. Contour map of Eti-Osa

Using the elevation data map and the down-scaled Intergovernmental Panel for Climate Change (IPCC) sea-level rise scenarios, Global Mapper software package was used to perform the *"Simulate Water Level Rise/Flood"* analysis. This was used to generate the spatial extent of the impact of the sea-level rise at each projected IPCC SLR scenario thus, output data of the simulation analysis. The output of this simulation analysis was projected to Minna Universal Transverse Mercator (UTM Zone 31) to share the same datum with the Eti-Osa boundary data (shapefile) to aid extraction (clipping) within the area of interest using Analysis Tools in ArcGIS window. The clipped data was overlaid on the LULC map of Eti-Osa in 2015 which is the base map to illustrate the spatial extent of the sea-level rise over its land covered area using ArcGIS 10.1 software platform. Thus, the impact of the sea-level rise at each scenario was evaluated. Figure 3 shows the graphical representation of the procedure for the analysis.

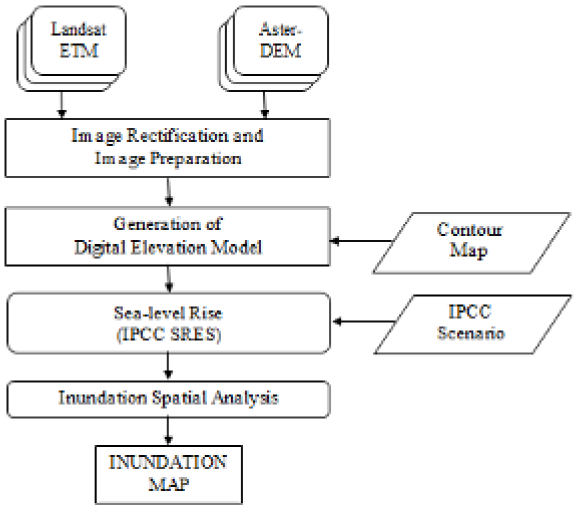

Figure 3. Sea-level Rise Inundation Model
(Source: modified after Shakirudeen et al., 2014)

RESULTS AND DISCUSSION

Urban Spatio-temporal Change in Eti-Osa between 2000 and 2015

The change in the spatial structure of the land use types in Eti-Osa between 2000 and 2015 is shown in figure 4. It illustrates the observable change graphically taking into consideration the variation in the land use classes examined. In 2000, the land use ratio was distributed such that water body (56.04%) had the highest percentage to forest/grassland (20.44%), to high density built-up (11.81%), to riparian forest (7.39%) to light density built-up area (7.39%) then bare land (0.76%). But in 2015, the ratio of distribution has changed such that water body still takes the largest ratio of 53.57%, followed by high- density built-up area with 16.62%, to light density built-up area with 15.21%, to forest/grassland with 7.06%, then riparian forest with 5.22% and bare land with 2.31%. This variation does not only illustrate the change in Eti-Osa but also the pattern of change and replacement of one class of land use type by another with the observed period. The statistical representation of this findings is tabulated in table 1.

The effect of urban growth in Eti-Osa accounts for the observed change in the land use type as against its initial state. This change threshold analysis has helped to delineate the observed changes; its magnitude and direction. Hence, the statistical result of this analysis has helped to identify that the influence of urban development has induces a change in a way that between 2000 and 2015, water body has reduced by 2.47% which might be as a result of huge land reclamation activities and seasonal change. Forest/grassland as drastically reduced by 13.38% which might be accounted for as an output of a very high rate of urban development by prospective developers. Also, result illustrates a 2.17% decrease in riparian forest due to frequent sand filling and stabilization of wetlands all to cater for the high demand for structural developments within areas of high land value.

Furthermore, 1.55% increase in the coverage area by bare land justifies the assumption that there has been a high degree of land reclamation and sand filling of the wetlands. The advent of urban development was made pronounced as the result of this study showed that high-density built-up area has increased by 4.81% and light density built-up area has experienced 11.60% increase. This gives an account of 16.47% increase of built-up area within the observation period of 15 years as peculiar to Eti-Osa (Nigeria). This observed change pattern was figured to be as a result of diverse human attempts of urban expansion which led to activities such as land reclamation, land stability and sand filling of a wetland, all done to cater for the expansion demands (Seto et al., 2012). See Table 1 for the comparison of the result of the change detection analysis.

Table 1. LULC change summary between 2000 and 2015

Land Use/ Land Cover	2000		2015		Percentage (%) change	Remark
	Per (%)	Area (Ha)	Per (%)	Area (Ha)		
Water Body	56.04	24857.64	53.57	23771.07	**-2.47**	***Decrease***
Forest/Grassland	20.44	9068.31	7.06	3131.01	**-13.38**	***Decrease***
Riparian Forest	7.39	3279.42	5.22	2315.52	**-2.17**	***Decrease***
High Density (Built-up)	11.81	5240.88	16.62	7370.28	**4.81**	***Increase***
Light Density (Built-up)	3.55	1574.91	15.21	6746.04	**11.66**	***Increase***
Bare land	0.76	339.03	2.31	1026.27	**1.55**	***Increase***
Total	**100**	**44267.58**	**100**	**44267.58**	-	-

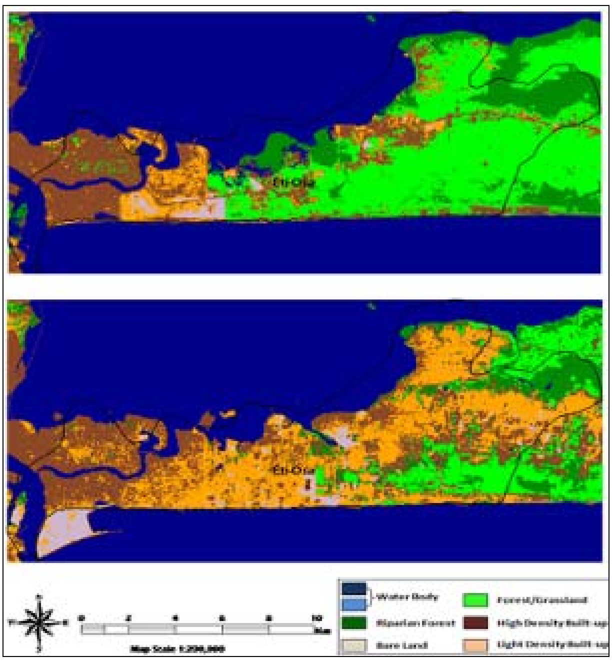

Figure 4. Land Use/Land Cover in Eti-Osa in 2000 (Up) and 2015 (Down)

From the findings derived from the change threshold analysis, attention was focused on illustrating the magnitude of observed change with a land use type. From the geo-spatial analysis performed, an estimate of 667.326 ha land area was observed to have been added to the initial land extent of the study area which is identified to be the proposed Eko Atlantic city site (see figure 4). Thus, the effect of urban expansion within the observed period of biodiversity loss such as land reclamation from water bodies, sand filling of wetlands and replacement of nature land cover with built surfaces are been illustrated in figures 5, 6 and 7. Therefore, this study has made it evident that indeed urban expansion in Eti-Osa has a great deal caused a high degree of depletion in natural ecosystem as present percentage of the built-up area has influenced reduction in the total land coverage area of riparian forest (wetland), forest/grassland and water body.

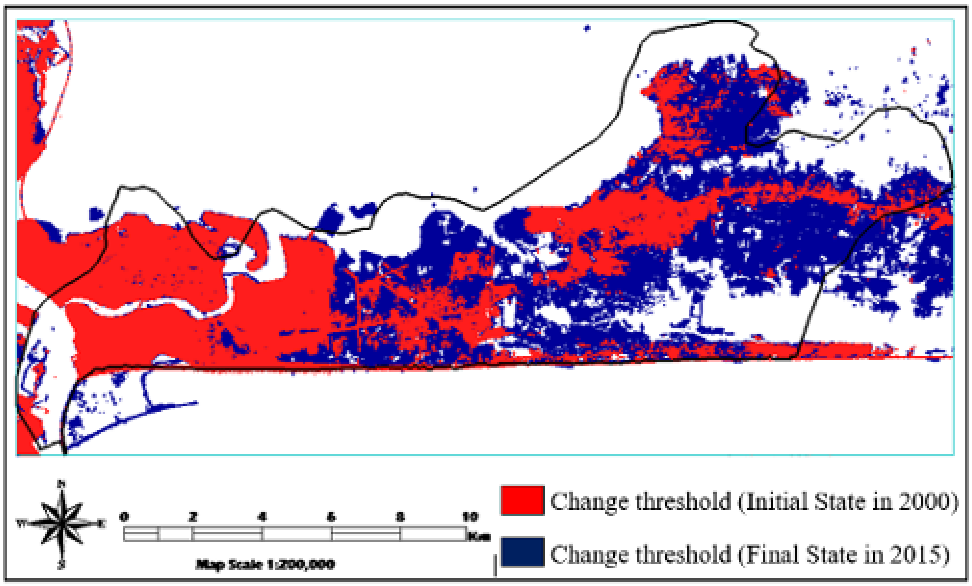

Figure 5. Built-up Area (High & Light Density) in 2000 and 2015 in Eti-Osa

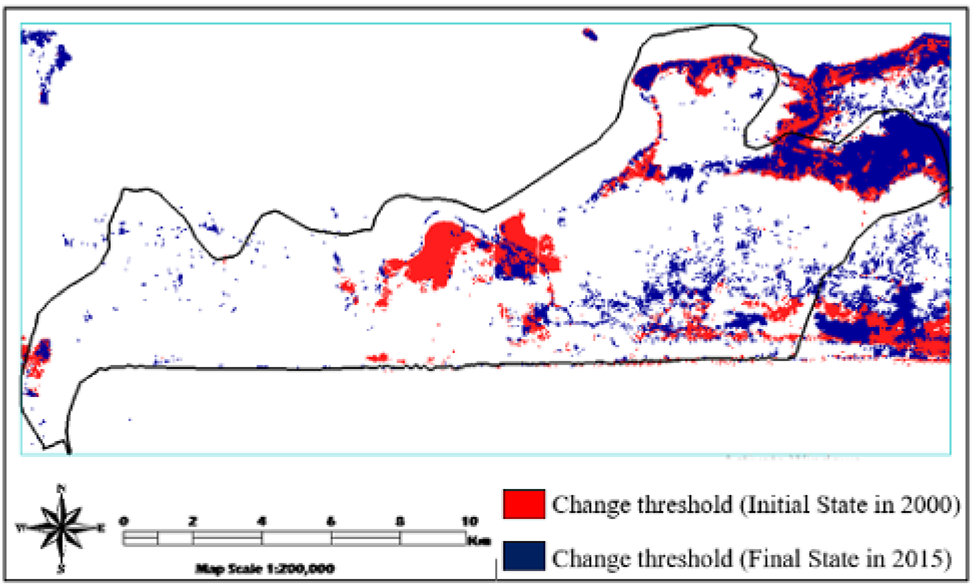

Figure 6. Riparian Forest in 2000 and 2015 in Eti-Osa

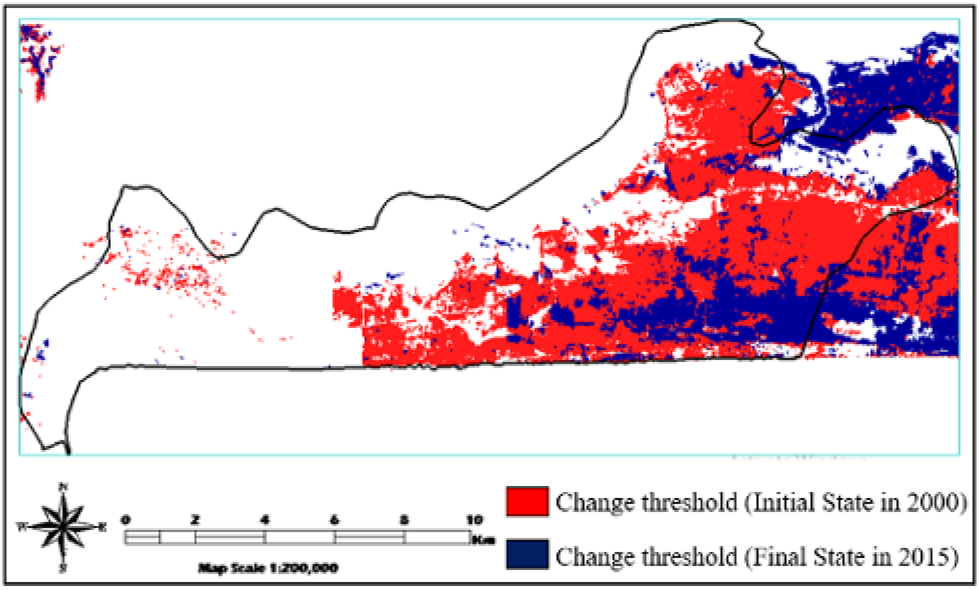

Figure 7. Forest/Grassland in 2000 and 2015 in Eti-Osa

Inundation spatial analysis

By adopting the IPCC downscaled scenarios and LULC map of Eti-Osa in 2015, the projection was made to forecast the potential impact of human interference and climate change on sea-level based on specific graduations at 0.5 meter, 1 meter, 2 meters, 5meters and 10 meters. Figure 8 shows the natural state of Eti-Osa environment in 2015 which was used as the base map for the inundation analysis. Thus, for 0.5 meter SLR scenario, it was estimated that approximately 7.14% of the total land area of Eti-Osa will be submerged leading to inundation of major prominent parts of Eti-Osa such as the proposed Eko Atlantic city, coastal shore (beaches), and several private/communal developments having direct access to the shore. An estimate of 7.47% of the land extent will be inundated at 1meter rise in sea level. At 2 meters rise in sea-level, 7.93% of Eti-Osa will be totally lost to water and 10.39% will be lost to water if there is a rise in sea-level at 5meters. For the graphically illustrated of outputs, see figures 9, 10, 11 and 12 respectively.

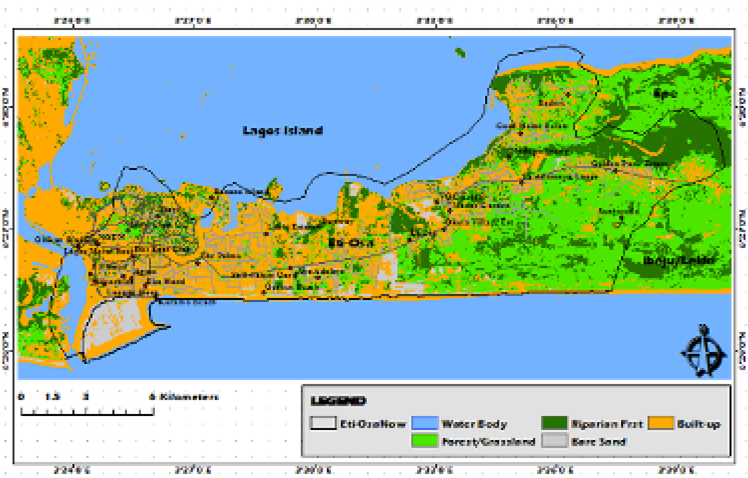

Figure 8. Classified Landsat 7 ETM+ (2015) image of Eti-Osa

Reasonable from the elevation data, a relatively large portion of Eti-Osa is just about 10 meters above sea-level thus, vulnerability to inundation with just a little pressure (such as natural disasters) acting on the water body. This aids the interest of making projections at 10 meters and 15 meters SLR projection. The output demonstrated facts beyond imagination as 64.16% of Eti-Osa will be wiped off at 10meters sea rise (figure 13) and approximately 83.68% of the total land area of Eti-Osa would be totally washed away at 15meters sea-level rise (figure 14). These two extreme sea-level rise would not leave Eti-Osa submerged by water but eventually cut away from main Lagos State land area. This, therefore, comes with an attendant extreme cost implication such that virtually most if not all government, private or communal owned developments must have been lost. Thus, the need to estimate the cost implications of each sea-level rise that have been projected.

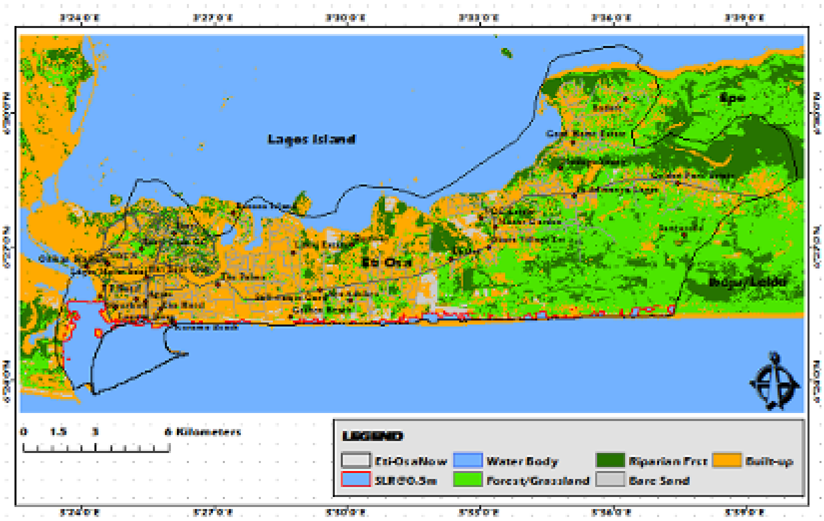

Figure 9. Sea-Level Rise at 0.5 meters in Eti-Osa

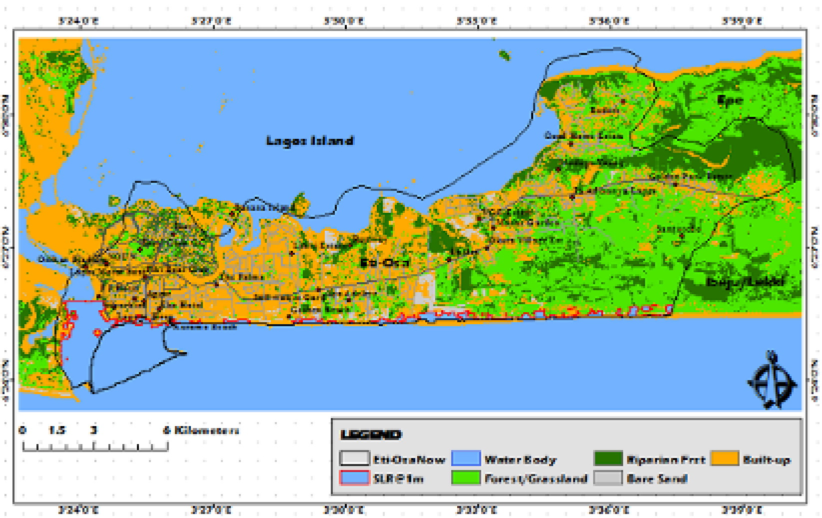

Figure 10. Sea-Level Rise at 1 meter in Eti-Osa

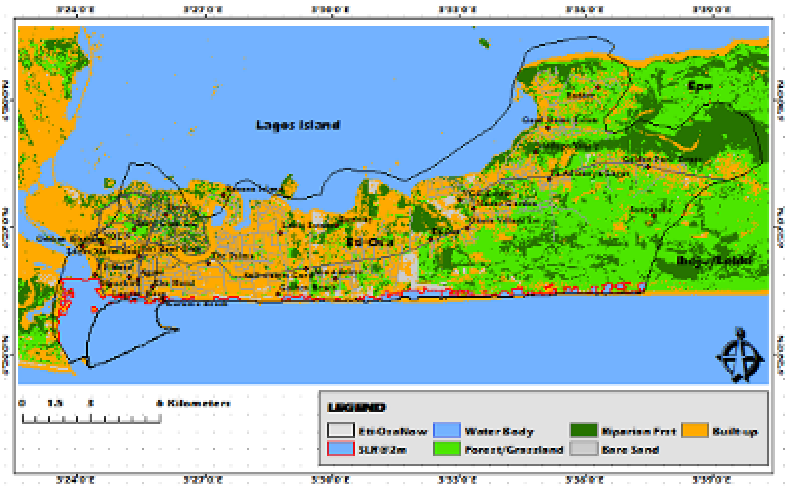

Figure 11. Sea-Level Rise at 2 meters in Eti-Osa

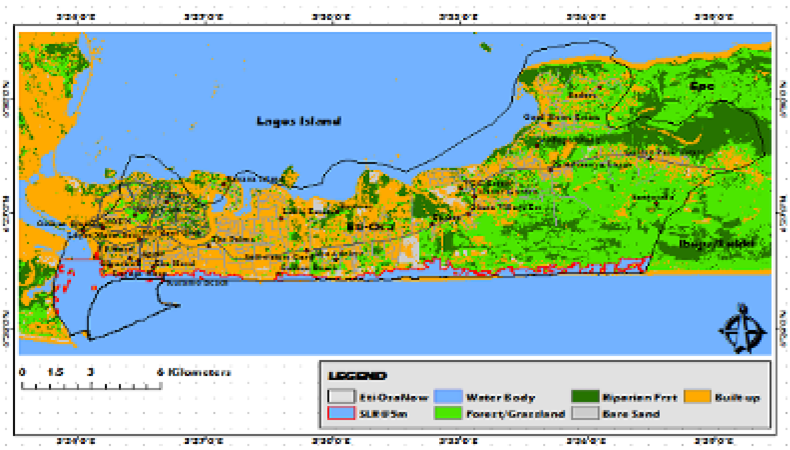

Figure 12. Sea-Level Rise at 5 meters in Eti-Osa

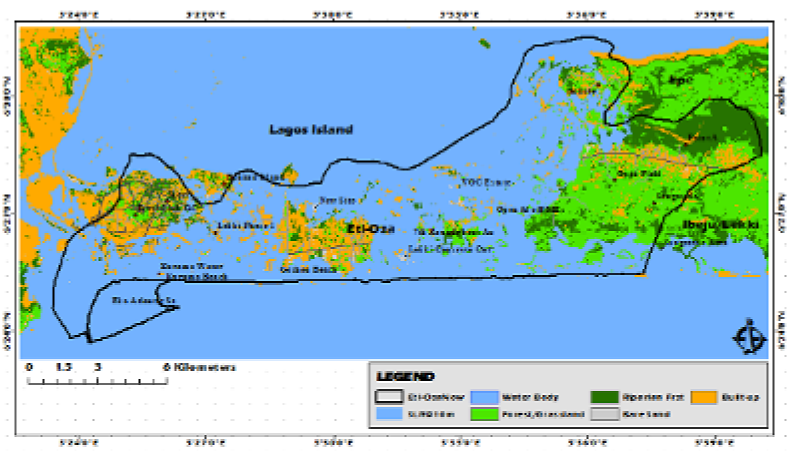

Figure 13. Sea-Level Rise at 10 meters in Eti-Osa

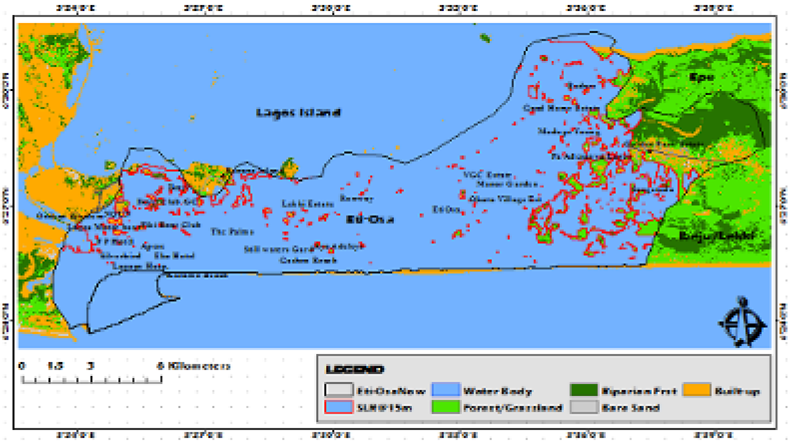

Figure 14. Sea-Level Rise at 15 meters in Eti-Osa

The result from this study shows the effect of human activities and urban development on the environment as it gives room for sea-level rise causing huge inundation and economic damage (McGranahan et al. (2007); Vidal (2013). Literature has revealed that the cost of acquiring a land (per square meter at the current exchange rate in August 2015) in Eti-Osa ranges relatively from N100, 000 ($500) to N 300, 000 ($1500). Therefore, an average of N 200, 000 ($1000) is estimated as the cost of land per square meter across Eti-Osa. Hence, statistical facts of each SLR scenario, the land extent in the area (Ha), Percentage coverage (%), major identified property damage and cost equivalent (in U.S Dollars) are compared in table 2.

Table 2. Sea-Level Rise and Cost implications

SLR Scenerio (m)	**Area (Ha)**	**(%)**	**Property damaged**	**Estimated Cost Value ($)**
0.5	1333.664	7.14	Eko Atlantic City Site, Beaches	13,330,709,534
1	1398.256	7.47	Private and Public Beaches	13,976,342,310
2	1484.908	7.93	Kuramo beach (Part)	14,842,476,990
5	1944.290	10.39	Kuramo beach, Silverbird Cinema (Total), Goshen beach, and Federal Palace Hotel (Partly inundated)	19,434,254,235
10	12011.795	64.16	Victoria Island Annex, Goshen Beach, Manor Garden, Federal Palace Hotel, Eko Hotel, The Palms Shopping Mall, Lekki Peninsula Scheme 1, Ajah community, Victoria Garden City (VGC) and Good Home Estate (Total), Banana Island (Partly inundated)	120,064,536,596
15	15665.414	83.68	Banana island, Ikoyi, Lekki Peninsula Scheme 1, Still water estate, Abraham Adesanya estate, Sangotedo (Total)	156,584,479,879
TOTAL	18721.626	100	187133009.6807456sqm	187,133,009,680

This study has made evident the impact of human developmental activities on our environment as peculiar to Eti-Osa such that a high degree of alteration of the natural ecosystem has been induced. Owing to the observed urban growth, there is now diverse forms of distortion and degradation of environmental from its initial balanced state (Odewaye, 2009; Ogundele et al., 2011). The advent of these developments has brought about several deleterious activities such as land reclamation from water bodies, sand filling of wetlands, excessive replacement of natural surface with impervious materials, dredging and huge removal of vegetation with built-up (Jongman et al., 2012; Craft et al., 2009). The present extent of urban expansion and a showcase of wealth have resulted in high risk urban development ideas such that entails building up of water fronts and beach resorts. Now governments and privately owned developments are taking the place of bare sand which is supposed to be its natural state.

Through GIS, it has been estimated that sand filling/land reclamation alone has added 667.326 Hectares (Ha) to the total land cover area in Eti-Osa LGA as at 2015. This is illustrated graphically in figure 15 as it’s said to be the proposed site of Eko Atlantic City. As a result of the pressures mounted on the water body from the proposed site and other pressures from different prospective developments within Eti-Osa, the sea level rise scenarios (at 10 meters and 15 meters) might become a reality owing to disasters that could emanate from the combining pressures.

CONCLUSION

Over the past decades, human interaction with the environment as studied in Eti-Osa (Nigeria), urban development has greatly influenced the structure of the immediate to environ such that the natural structure and land cover patterns have been distorted. This is mainly a result of the upsurge in the urban population. The result of this study has illustrated the magnitude and direction of change over time and justified that the major contributing factor of environmental degradation hangs on urban development. A major factor used to evaluate the impact of urban development on the environment as an effort of human activities is the Sea-level rise analysis. This analysis showcased that Eti-Osa among other low-lying coastal urban communities in Nigeria would be greatly inundated with just a few meters rise in the level of the sea. It also examined the cost implication of the projected inundation and concludes that though the sea-level rise is forecasted on the global scale, the phenomenon is best described theoretically than having it in reality as projected for Eti-Osa. This makes it evident that from the observed accelerated population growth, the pattern of urban expansion, induced changes in land use type, biodiversity loss and gross depletion in the ecosystem, the possible continuity of this degradation is certain. Thus, there is a great need to strictly enforce sustainable development policies and strategies that can still help check the depletion rate. Also, Government authorities and concerned institutions should devote more resources to public awareness of the deleterious effect of gross alteration of the natural environment. More so, the advent of the use of sophisticated remote sensing techniques for environmental monitoring and development control should totally be adopted for observation in the developing countries.

Acknowledgements

Sincere appreciation goes to Prof. O. B. Akinbamijo, and Mr Omotola Adedeji for their technical observations and scientific suggestions. Thanks to USGS that made the needed imageries readily available in their online archive.

REFERENCES

Adesoji D. J. (2011), *Urbanization challenges and housing delivery in Nigeria: The need for an effective Policy framework for Sustainable Development*, International Review of Social Sciences and Humanities, 2(1), 176-185.

Arthurton R., Korateng K., Forbes T., Snoussi M., Kitheka J., Robinson J., Shah N., Taljaard S., Monteiro P. (2006), *Chapter 5: Coastal and marine environments*, In: Jennifer C. ed. Africa Environment Outlook 2: Our Environment, Our Wealth. Nairobi, Kenya: United Nations Environment Programme (UNEP), 2006, 187-227.

Bai X. (2001), *Industrial relocation in Asia: A sound environmental management strategy?* Environment, 44(5), 8-21.

Bo T., Liquan Z., Xiangrong W., Yunxuan Z., Wen Z. (2010), *Forecasting the effects of sea-level rise at Chongming Dongtan Nature Reserve in the Yangtze Delta, Shanghai, China*, Ecological Engineering, 36(10), 1383–1388.

Brammer H. (2010), *After the Bangladesh Flood Action Plan: looking to the future*, Environmental Hazards, 9(1), 118–130.

Brammer H. (2013), *Bangladesh's dynamic coastal regions and sea-level rise*, Climate Risk Management, 1, 51-62.

Climate Change Science Program [CCSP] (2009), S*ynthesis and assessment product 4.1: coastal sensitivity to sea-level rise: a focus on the Mid-Atlantic region*, U.S. Climate Change Program, Washington, DC.

Craft C., Clough J., Ehman J., Joye S., Park R., Pennings S., Guo H., Machmuller M. (2009), *Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services*, Frontiers in Ecology and the Environment, 7(2), 73–78.

Diop S., Arthurton R., Scheren P., Kitheka J., Koranteng K., Payet R. (2011), *The coastal and marine environment of Western and Eastern Africa: challenges to sustainable management and socioeconomic development,* In: Wolanski E. and McLusky D eds. Treatise on Estuarine and Coastal Science. Amsterdam: Academic Press, 2011, 315-335.

Eriksen S., Aldunce P., Bahinpati C., Martins R., Molefe J., Nhemachena C., O'brien K., Olorunfemi F., Park J., Sygna L., Ulsrud K. (2011), *When not every response to climate change is a good one: Identifying principles for sustainable adaptation*, Climate and Development, 3, 7–20.

IPCC (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Summary for Policymakers*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.

Jongman B., Ward P. J., Aerts J. C. J. H. (2012), *Global exposure to river and coastal flooding: Long term trends and changes*, Global Environmental Change, 22(4), 823- 835.

Masroor H., Dongmei C., Angela C., Hui W., David S. (2013), *Change detection from: From pixel-based to object-based approaches*, ISPRS Journal of Photogrammetry and Remote Sensing, 80, 91–106.

McGranahan G., Balk D., Anderson B. (2007), *The rising tide: Assessing the risks of climate change and human settlements in low elevation coastal zones*, Environment and Urbanization, 19(1), 17–37.

Nwokoro I., Dekolo S. (2012), *Land Use Change and Environmental Sustainability: the case of Lagos Metropolis*, In: Sustainable City 2012, 7th International Conference on Urban Regeneration and Sustainability, Anacona Italy 7-9 May 2012.

Odunuga S., Badru G., Mumin B. (2014), C*limate change, sea level rise and coastal inundation along part of Nigeria Barrier Lagoon Coast*, Journal of Applied Sciences and Environmental Management, 18(1), 41-47.

Odunwaye L. (2009), *Challenges of Sustainable Physical Planning and Development in Metropolitan Lagos*, Journal of Sustainable Development, 2(1), 159-171.

Ogundele F. O., Ayo O., Odewumi S. G., Aigbe G. O. (2011), *Challenges and prospects of physical development control: A case study of Festac Town, Lagos, Nigeria,* African Journal of Political Science and International Relations, 5(4), 174-178.

Shakirudeen O., Gbolahan B., Olalekan M.B. (2014), *Climate change, sea level rise and coastal inundation along part of Nigeria Barrier Lagoon Coast*, Journal of Applied Sciences and Environmental Management, 18(1), 41-47.

Syvitski J.P.M., Kettner A. J., Overeem I., Hutton E.W.H., Hannon M.T., Brakenridge R. G., Day J., Vörösmarty C., Saito Y., Giosan L., Nicholls R.J. (2009), *Sinking deltas due to human activities*, Nature Geoscience, 2, 681–686.

Vidal J. (2013a), *Sea change: the Bay of Bengal's vanishing islands*, The Guardian (ONLINE) Version 1.0 (Accessed 18 March 2014) Available from: http://www.theguardian.com/global-development/2013/jan/29/sea-change-baybengal-vanishing-islands

Vidal J. (2013b), *Tigers under threat from disappearing mangrove forest*, The Guardian (ONLINE) Version 1.0 (Accessed 18 March 2014) Available from: http://www.theguardian.com/environment/2013/jan/29/sunderbans-disappearing-mangrove-india-bangladesh

Submitted:	Revised:	Accepted and published online
May 18, 2016	July 25, 2016	Octomber 25, 2016