EFFECT OF URBANIZATION ON WETLAND AND BIODIVERSITY IN THE MANGROVE FOREST OF LAGOS STATE, NIGERIA

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Abstract: This study tries to examine the effect of urbanization on wetland and biodiversity in the mangrove forest of Lagos state, Nigeria. Two scenes of Landsat TM (Thematic Mapper) of 18th December, 1984 and ETM+(Enhanced Thematic Mapper) of December 2006 were processed to extract the wetlands, mangroves and water bodies across the area of study. ENVI software was used along with parallelepiped supervised classification in processing the Land-sat images. Results showed that the mangrove wetlands and swamps decreased annually both between 1990 and 2000. It was further seen that the highest decline in the Mangrove was recorded in Epe LGA while that of swamps shows that the highest decline in swamp wetland occurred in Epe and Ibeju-Lekki council area of Lagos State. Results further show that mangroves which were widespread in seven council areas around these lagoons in 1990, have dwindled to only four councils in 2000. In conclusion therefore, the relevance of spatial plans employing image processing analysis and geo-information in revealing wetland loss within the study area was necessary. Relevant recommendation was also made in this study.

Keywords: Geographic information system, Lagoon, spatial changes, wetland

Introduction

Wetland is however composed of a number of physical, biological and chemical components such as soils, water, plants and animal species, and nutrients. This wetland ecosystem structure (that is, the tangible items) yields benefits, which are of direct use value to humans. Many tropical wetlands are being directly exploited to support human livelihoods. Processes among and within these wetland components allow the wetland to perform certain functions such as flood control, shoreline stabilization, water purification, and general products such as wildlife, fisheries and forest resources. In addition, there are ecosystem scale attributes such as biological diversity and cultural uniqueness/heritage, that have value either because they induces certain uses or because they are valued themselves. According to Turner (1990), wetland ecosystems account for about six per cent of the global land area and are considered by many authorities to be among the most threatened of all environmental resources. Urban populations and wetlands are said to have been engaged in a turbulent, somewhat symbiotic marriage since the dawn of civilization. Being essential for human wellbeing, wetlands have been progressively lost and degraded from human activities since then. The rate of their loss is known to be greater than for any other type of ecosystem (UN-Habitat, 2010). Most of the physical losses have been due to the conversion of wetlands to other land-uses, for example residential and agricultural. Rapid urbanization and urban areas are known to generate negative impacts on the environment (UN-Habitat, 2010) as they lead to changes in landscape patterns, ecosystem functions and their capacity to perform functions in support of human populations. This is especially so when rapid or unplanned growth occur in areas of highly vulnerable systems such as wetlands. The conversion of large tracts of wetlands into built – up area results in increased impervious surfaces which can lead to flooding and altered aquifer recharge (Odunuga & Oyebande, 2007).

However, due to the urgent need of people seeking for a greener pasture demand of the rapidly growing urban population, the high rate of unemployment in most urban cities, and the high poverty level, urbanization is presently taking over natural wetlands in and around urban cities. Uncoordinated and improper growth of Urbanization has promoted disease diffusion to most of the aquatic life within the Mangrove forest area of Lagos State. Due to the increasing population pressure, increasing and urgent demand for food, high cost of land and the almost unavailability and unaffordable cost of land in Lagos Metropolis, urbanization activities and other developmental processes are competing for land, especially wetlands around Ikorodu and Kosofe areas of Lagos State. Asangwe (2006) estimated that about 60 per cent of Lagos metropolis was originally natural wetlands.

Hence, this study tackled the quantification of Urbanization especially wetlands and its effects on the biodiversity, causes, land-use dynamics and the health implications through direct observations using remote sensing, questionnaire administration, disease vector studies, nutritional supply studies and GIS models within an ecosystem approach. The objectives of this research is to evaluate the impact of urbanization on wetlands and biodiversity on the mangrove forest of Lagos State, Nigeria; to map and generate the inventory of wetlands and biodiversity within the study area during the period of investigation and to evaluate the spatio-temporal changes in wetland and biodiversity in the Mangrove Forest within the study area over a specific period.

Urbanization which is the conversion of land to uses associated with growing population and economy has been recognized as having a worldwide trend. More than 50% of the world's population currently resides in cities and urban settlements with this shift to urban living expected to continue at rates of almost 1.6% per annum worldwide. The highest urbanization rates were expected in developing and least developed countries (UN-Habitat, 2010) while 95% of the net increase in global population would be in cites of the developing world (Zhang *et al.*, 2008) such as Lagos. As part of this trend, the coastal zones are known to be home to nearly 75% of the global population (Asangwe, 2006). Lagos city has grown from a settlement of about 3.85 km^2 in 1881 to a huge metropolis of over 1,183 km^2 in 2004 (Okude & Ademiluyi, 2006). In consequence, the population which was negligible in those years had risen from about 5.7 million in 1991 to about 9.1 million in 2006 (National Population Commission, 2006) with average population density of 20,000 persons/km^2 (Presidential Committee on the Redevelopment of Lagos mega-city Region, 2006). The nature of population growth in some of the local councils around the two lagoons between 1991 and 2006 is a reflection of the urbanization pressure in the study area (Table 1). For instance, while

Ikorodu council area which is rapidly developing had a population density of 7,207 persons/km^{2}in 2006, Etiosa LGA had 3,423/km^2, while densely developed Lagos Mainland, Shomolu and Lagos Island LGA's had densities of 28,154; 39,053 and 39,661 persons/km^2, respectively in 2006 (Mehrotra *et al*., 2009). The obvious consequence of this population expansion on natural resources in a coastal terrain with about 44% of the study area being water bodies and wetlands in 1990 (Figure 1) is development on marginal lands within or fringing urbanized areas.

Table 1: Population figures for some LGA's around the lagoons

Local Government Area	1991 Population Census	2006 Population Census
AmuwoOdofin	225,823	328,975
Apapa	154,477	222,986
EtiOsa	157,387	283,791
Ikorodu	-	535,619
Kosofe	412,407	682,772
Lagos Island	165,996	212,700
Lagos Mainland	273,079	326,700
Shomolu	358,787	403,569

Source: National Population Commission of Nigeria (2006)

Materials and Method

Study area

Lagos State lies approximately between Longitude 2^{0}34^l and 3^{0}42^l E and Latitude 6^{0}24^l and 6^{0}42^l N. This is situated within the Southwest coast of Nigeria and stretches from the Nigeria-Benin boarder to the East of the village of Agwerige where the coastline started its inflection southwards. It is bounded in the South by Atlantic Ocean, in the West by Benin Republic and in the North and East by Ogun State. The state remains the smallest state with a total land mass of 3,577 km^2 and the water bodies covered an area of about 256.26 km^2. The population density as a result of urbanization is about 1,300 person/km^2, which is about 15 times the country's average (Oyebande *et al*., 2004). Lagos state remains the most urbanized state in Nigeria with her 60,839 hectares of land mass or 17% of the total area occupied by lagoons and waterways. The state has a low lying terrain with about 3 – 5 m above sea level and is drain by river Ogun, Osun and other tributaries.

The area is covered with clay-sandy soil along the coastal axis in the south and clay-loamy soil at the interior part. The vegetation of the region is that of coastal swamp and marsh forest and is mostly of Mangrove vegetation. The climate of the area is influenced by two air masses, namely: Tropical maritime and the Tropical continental air masses. The temperature is high throughout the year with an annual mean temperature of about 26.77ºC. The area records an average annual rainfall of about 1830 mm, with maxima in June and September.

Data and image processing

Due to lack of digital data, several hardcopy 1:25,000 topographic maps were scanned, geo-referenced and digitized for baseline data. The digitized maps were then edge - matched to produce a seamless mosaic. Two scenes of Landsat TM (Thematic Mapper) of 18th December, 1984 and ETM$^+$(Enhanced Thematic Mapper) of December 2006 were processed to extract the wetlands, mangroves and water bodies across the area of study. Bands 3, 4 and 5, were used for colour composite in order to identify the wetlands, mangroves and water bodies distinctly. The wetlands were identified as having a greenish spectral signature, while the mangroves had the dark green colour as their trademark. With field and ancillary data, these were then uniquely assigned as regions of interest or training samples. Using ENVI (Environment for Visualizing Images) software, a parallel piped supervised classification was then carried out on the trained classes and then used to extract the wetlands from the entire multispectral imageries of the two dates independently.

Fig 1: Map of Nigeria showing the study area

Data processing analysis

Geometric correction was performed on all images using a Landsat MSS image of same area from 2009 as referenced. At least 30 ground control points (GCPs) were used to register the image to Nigeria Transverse Mercator (NTM) system. GCPs were dispersed through-out the DMA area yielding a RMS error of less than 0.5 pixels. A first order polynomial fit was applied and images were re-sampled to 30m output pixels using nearest neighbor method. All three reflective bands were used in image classification. Parallelepiped was used as non-parametric rules. GIS tools, such as area of interest (AOI) were applied to the data using visual analysis, reference data as well as local knowledge to split and record these covers so they more closely reflected their true classes (Dewan, and Yamaguchi, 2009). By applying these techniques, the result obtained using supervised algorithm with Maximum likelihood technique as parametric rules and Parallelepiped as non-parametric rule which ultimately improved the output results.

In addition, geospatial data including municipal boundaries, road network, geomorphic units and elevation data were used to produce GIS layers from different sources. A ground truth map was prepared for locating training pixels on the image and 80 reference points were collected using Global Positioning System (GPS). Magellan Triton 300 Handheld GPS was used for this task. This GPS information was overlaid with the image in GIS to select training areas and for accuracy assessments. Confusion matrix along with error of omission & error of commission (Lillesand and Kiefer, 2010) was used for accuracy assessment. Over all accuracy was 87% to 92.5%. Classified images were analyzed using ArcGIS 9.3.1 software. With some additional shape file of permanent water bodies, rivers and DMA boundary, final output maps of wetlands of different years in DMA were prepared in GIS environment.

Results and Discussion

Results showed that mangroves decreased by about 77% from 88.51 to 19.92 km^2 at 3.12 km^2/yr deficit while swamps decreased by 52% from 344.74 to 165.37 km^2 at a loss of 8.15 km^2/yr both between 1990 and 2000 (Table 2). Results further showed that the mangroves which were widespread in 7 (seven) LGA's in 1990 have dwindled to only four (4) LGA's in 2000 with about 4km^2 and above. Epe, Etiosa, Ikorodu and Kosofe in that order were the councils with the largest area of mangroves in 1990 of 24.76; 22.65; 19.43 and 17.94 km^2, respectively.

Similarly, swamps which had sizeable presence in five (5) LGA's in 1990 had whittled to four (4) councils with about half of their sizes converted in 2000. The relative loss of wetlands (mangrove and swamps) and gains by succeeding land cover mainly bare land and built – up areas are displayed in Fig. 1.

Table 2: Showing changes in areas of swamps and the mangrove between 1990 and 2000

Land cover	1990 km^2	2000 km^2	Changes km^2	% of Change (1990-2000)
Swamps	344.75	165.37	-179.37	-52.03
Mangrove	88.51	19.92	-68.39	-77.50
Total area	433.26	185.32		

Total study area: 2,561.261 km^2

In Table 3 below between 1990 and 2000, respectively; the following results were obtained. Vegetation with 218.01 and 250.24 sq.km recorded 32.23 sq.km change in area extent during a period of 10 years and a 14.78% change and an annual change rate of 1.48. Thus again of vegetative cover was recorded as a result of the rejuvenation of the reclaimed Ikorodu wetlands. Forested Wetland had 157.44 and 46.22 sq.km recorded -111.22 sq.km change in area extent with -70.64% changes and an annual change rate of -7.06 recorded the highest loss in the period under consideration. Non forested wetland with 21.63 and 19.01 sq.km recorded -2.62 sq.km change in area extent with -12.11% changes and an annual change rate of -1.21. Built up area with 3.12 and 62.62 sq.km recorded 59.50 sq.km change in area extent with 1907.05% change and an annual change rate of 190.71. Bare land with 65.28 and 92.85 sq.km recorded a 27.57 sq.km change in its area extent at a 42.23% change and an annual change rate of 4.22. Water body with 198.97 and 193.51 sq.km with a change in its area extent at -5.46 sq.km and a -2.74% change and an annual change rate of -0.27. As Forested Wetland accounted for a major loss, built up accounted for the greatest gain for period under review.

Table 3: 10 years annual rate of change between $t_0 – t_1$ (1990 - 2000)

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

Source: GIS analysis of interpreted remotely sensed data (2014)

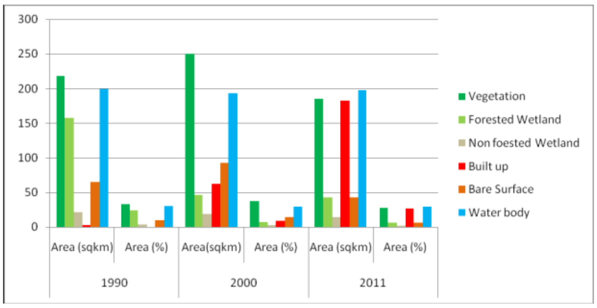

Fig. 3: The frequency table between 1990 and 2000

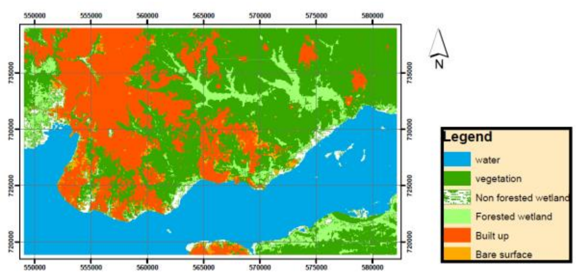

Fig 4 and 5: Local Governments selected for this study between 1990 and 2000

The highest decline in the Mangrove was recorded in Epe L.G.A where it declined at 0.95 km^2/yr deficit followed by Etiosa where it receded by 0.82 km^2/yr. The highest decline in swamp wetland occurred in Epe and Ibeju-Lekki council at a rate of loss of 3.27 km^2/yr followed distantly by Ikorodu LGA where they were converted at 1.02 km^2/yr. The main drivers of this conversion both in the north and south of Lagos Lagoon have been determined in Obiefuna *et al.* (2012) to be principally urban development. Consequently, the disappearance of the mangrove in the western part of Etiosa LGA for example is traceable to development which started through the Lekki Peninsula Residential Scheme 1 in 1980's.

Table 3: Coverage of swamps and mangrove per LGA in 1990

LGA	Swamps	%	Mangrove	%
Amuwoodofin	0.06	0.02	3.16	3.57
Apapa	0.01	0.00	2.30	2.60
Epe	163.38	47.39	24.76	27.98
Etiosa	12.69	3.68	22.65	25.59
Ibeju-Lekki	125.78	36.48	1.55	1.75
Ikorodu	41.23	11.96	17.20	19.43
Kosofe	1.58	0.46	15.87	17.94
Lagos Island	NIL	NIL	NIL	NIL
Mainland	NIL	NIL	0.73	0.83
Somolu	NIL	NIL	0.29	0.32
Total	**344.75**	**100**	**88.51**	**100**

The distribution of mangrove around the Lagos Lagoon attests to the brackish nature of the Lagoon waters and possibly symptomatic of the extent of marine intrusion from the Atlantic Ocean. Conversely its absence around the Lekki-lagoon is indicative that the Lagoon is of fresh water. The remnants of mangrove and swamps along Omu creek in Etiosa and Ibeju-Lekki L.G.A's (north of Lekki-Epe expressway) are currently under stress from residential development accelerating in the area. At the Local council level the surviving mangrove in order of magnitude are found in Ikorodu, Etiosa, Keosofe, and Ekpe LGA's all on the Lagos Lagoon. Likewise, the remaining swamp wetland are in order of magnitude also largely in for local councils. The increasing flooding in the metropolis from imperviousness and extreme events linked to climate change call for more proactive measures to conserve the surviving wetland for flood storage and ecological capital, to do this requires appropriate inventory and mapping at requisite scale.

Table 4: Coverage of swamps and mangrove per LGA in 2000

LGA	Swamps	%	Mangrove	%
Amuwoodofin	NIL	NIL	0.88	4.41
Apapa	NIL	NIL	0.95	4.79
Epe	91.37	55.25	3.93	19.70
Etiosa	1.12	0.68	4.52	22.68
Ibeju-Lekki	53.94	32.62	0.46	2.31
Ikorodu	18.87	11.41	4.70	23.57
Kosofe	0.07	0.04	4.35	21.82
Lagos Island	NIL	NIL	NIL	NIL
Mainland	NIL	NIL	0.14	0.70
Somolu	NIL	NIL	NIL	NIL
Total	**165.37**	**100**	**19.95**	**100**

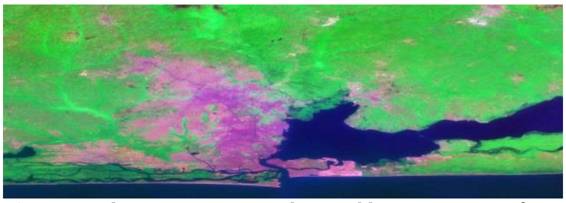

Fig. 3: Development pressure at Ibeju-Lekki Mangrove as of 1990
Source: Google Earth (2012)

Wetlands have significant impact on local ecology and biodiversity (Mitsch *et al.*, 1994). The depletion of wetland includes loss of biodiversity, ecological flood retention and reduces acquifer recharge, loss of breeding grounds and livelihood. The depletion of wetland and their dependent species not only translate into biodiversity loss into loss of carbon sink substrate nutrient recycle and other ecological services. An economic implication of the loss of mangrove is the loss of tidal breeding ground for several fish species (Okude and Ademiluyi, 2006); these impacts on the food webs through the loss of sources of fish protein in addition to disruption in livelihood of fishermen. The rapid rate of loss of wetland and the attendance necessitate urgent action to conserve the few remaining ones along the vision sustained in the area by Lekki Conservation Center/Nigeria Conservation Foundation (NCF). Although the legal and institutional frameworks for wetland conservation are in place in the country (Oyeband *et al*., 2004) made submission on their effectiveness to the effect that: (a) wetland conservation in Nigeria as a whole still lags behind their exploitation and degradation (b) the greatest problem confronting wetland conservation continues to lie in the adequate capacity to enforce existing environmental laws either at the Local council, State or Federal level (c) initiative to conserve the wetland previously have been driven largely with financial support of international organizational such as IUCN, WWF and development partners in conjunction with NCF.

Conclusion and Recommendation

It is true that urbanization in Lagos city would not be stopped (Mark *et al.*, 2001), but these should be based on further specific studies and understanding of the hydrological system of the area, not just demand driven unplanned expansion. In addition, drainage in Lagos is strictly controlled by land-relief and hence by gravitational drainage (Sultana *et al*., 2009). Special care should be given to the development and alteration of the existing water bodies so that natural hydrological condition can cope with the artificial structural actions (Winter, 1999). Water management must be the first concern for any development in Lagos metropolis because of its natural settings. We therefore recommend that the state authorities through the ecological fund could compensate and acquired for public interest the remaining critical mangrove and swamps in their inventoried local council. Responsible NGO's, co-operate bodies, tertiary institution, may be prevail upon to adopt, conserve and managed some of these for research, recreation and cooperate social responsibilities. The Geographic Information System, Remote Sensing approach and image processing approach should be employed for seasonal map updating as a means of monitoring construction activities on this endangered land forms. Higher resolution datasets are therefore recommended for effective discrimination amongst all land-uses of interest. A detailed land use/land classification system should be designed for effective monitoring, mapping and management of land-use activities within the city. National policies which support wetland conservation and promote appropriate legislation should be developed. National Wetland Committee should be established so as to improve the qualitative and quantitative information on National ecosystems. Environmental Impact Assessment before any major industrial project is sited should be encouraged.

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