Land Use Change and Impact on Biodiversity in Bonny Island using Remotely Sensed Data

Daddy Dappa and Benjamin Ndukwu
Institute of Natural Resources, Environment and Sustainable Development.
University of Port Harcourt, East-West Road, PMB 5323 Port Harcourt. Rivers State. Nigeria
allisonbyf@yahoo.com, Benjamin.ndukwu@gmail.com

Abstract—The study assessed land use change and impacts on biodiversity in Bonny Island using remotely sensed data. Both primary and secondary data sources were used for the study. The primary data sources involved downloaded images of Bonny Island between 1986 and 2016 of spatial resolution 30m x 30m; and the selection of training sites ground trothed along with their geographic coordinates using GPS. The images were imported to ArcGIS 10.5 whereby the bands of the images were combined using COMPOSITE module. The shape file of Bonny was generated in ArcGIS 10.5 and was used to clip the false colour composite image of each year. Accuracy assessment was performed on the 2016 image only using ground trothed data obtained by selecting one hundred training sites in the study area. Maximum likelihood supervised classifications were performed in ERDAS IMAGINE 9.1 on the land sat images. The vegetation make up of selected forests were assessed using quadrats of 20m x 20m, laid in each selected area. Change in land use size (km2) and percentage (%) change were computed using LUI-LUF/LUI x 100. Findings revealed that between 1986 and 2016, vegetation size reduced from 434.10km^2 to 349.52 km^2, while built up land use increased significantly from 32.55km^2 to 118km^2. The total change (loss) in size (spatial extent) of vegetation was -84.58 km^2 (-20.33 % change), while the size of built up area increased (gained) +85.67 (+235.22% change). Species diversity present in the study area were identified and documented to serve as a base line for further studies and impact assessment in years to come. Findings revealed that land use changes in Bonny Island is gradually impacting on biodiversity through vegetation loss and it can be attributed to the Oil and Gas activities and Urbanization in the area

Index Terms— Biodiversity, Land-use, Land-cover, Geographic Information System, Remote Sensing,

1 Introduction

Globally, activities such as urbanization, industrialization, farmland reclamation, changing climate and introduction of invasive species, which are caused by humans, are of great threat to ecosystems and its concerns. [1], [2]. Land-use change and land-cover change (LULCC) are terminologies used one for another to explain land changes but the two words have different meanings. Land-cover is a term that connotes characteristics, both the ones made by man and the ones not made by man, which are on the surface of the earth. Typical example(s) are deciduous forest, wetland, built environment, grassland, water etc. While land-use is the various activities or uses that land is been put to. [3].

With the overall objective of setting up the connection between land use changes and resultant impacts on natural resources, it is essential to acquire land-cover and land-use data of varying temporal and spatial scales from local to worldwide using Remote Sensing and Geographic Information systems. Such information is a requisite for spatial planning at different levels globally [4].

Biological diversity is undoubtedly a foremost component of ecological resources that is vital to guarantee the continuous existence of man and other life forms. Contemporary Literature divulges man's role in shaping the environment through urbanization, industrialization, deforestation, environmental pollution, and waste pollution as major anthropogenic factors causing biological diversity loss.

Tracking and monitoring the effects and threats to biodiversity because of urban land use patterns can aid in the slowing down and decline of these problems. The slowing down process is very expedient to city planners and developers. Remote sensing coupled with geo-spatial techniques is highly expedient in assessing land use change. These techniques combined can provide high spatial definition data and methods needed to pinpoint the magnitude and course of change.

Given the enormous and rapid urban expansion and industrialization of Bonny Island, and perspective of the scientifically accepted sensitivity of Island biodiversity worldwide, a study to assess land use impacts on Bonny is long overdue and is an effort to bridge research gap.

Aim and Objectives

The aim of the study is to assess land use changes and impacts on biodiversity in Bonny Island using remote sensing techniques. The following objectives guided the study:

(i) To identify and map out land cover classes in Bonny Island between 1986 and 2016

(ii) To determine the periodic changes in land use and vegetation size in Bonny Island between 1986 and 2016

(iii) To determine the percentage change in land cover classes between 1986 and 2016

(iv) To determine the plants species types, composition and diversity in selected areas of vegetal cover in the study area

Materials and Method

Study Area

Bonny is an Island in Rivers State, it is located in the southern part of the state and adjacent to Port Harcourt in the Niger Delta region of Nigeria (Figure 1.1). It is domiciled geographically on latitudes 8^0 22′ N and 8^0 31′ N and longitudes 5^0 3′E and 5^0 19′E (Figure 1.2). Bonny comprise two basic fragments – the territory and the hinterland. The territory contains Bonny Island and its portions, specifically the Main Island (Township), Akiama, Iwoama, Sandfield, Aganya, Ayambo, Orosikiri, Workers Camp, and some remote angling settlements lying along the Bonny River's coastline. Finima is a native group arranged along Bonny Island. The hinterland incorporates the town groups that fill in as home to locals of Bonny Kingdom.

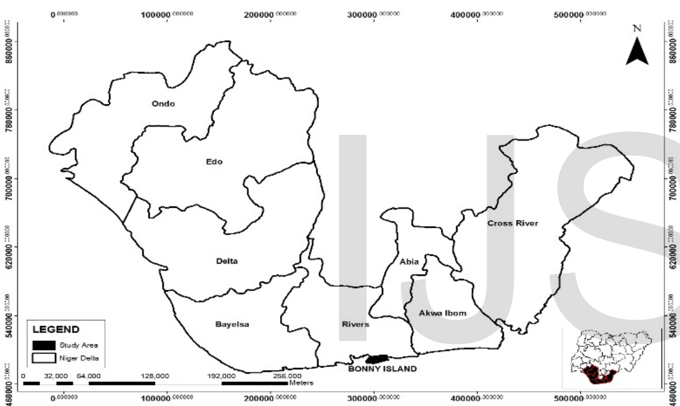

Figure 1: Map of Niger Delta showing the Study Area

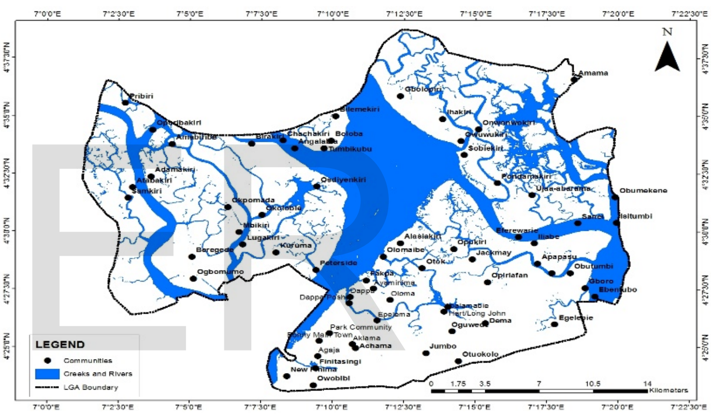

Figure 2: Map of Study Area (Bonny Island)

Reconnaissance Survey

This survey was conducted to ascertain and provide empirical evidence (ground truthing) of locations in reference to the land-use and land-cover types in Bonny Island. Global Positioning System (GPS) was employed in establishing the positions of various vegetative cover and other land-use/land-cover types in Bonny Island. The various types of landuse in the area were subsequently identified and rewarded.

Research Design

This describes the methods that the researcher choose to incorporate the various aspects of the study in a rational and intelligent way, ensuring effective addressing of the questions the research seeks to answer; it constitutes the outline for the gathering, estimation, and examination of information. The Longitudinal research design was utilized for the study due to the fact that the exploration configuration depicts examples that sets up the direction and immensity of causal connections and relationships.

Data Sources

This study utilized two sets of data (Primary and secondary data). The data included landsat satellite imageries gotten from the official website of United States Geological Survey (USGS). Three landsat images with a spatial resolution of 30x30 meters were used and the details can be found in Table 1. These years (1986, 2000 and 2016) were selected and used for analysis because they provided clearer images that need little or no image correction procedures. Also, images taken during the dry season were chosen because the spectral signatures of the different landcover types were appropriately distinguished and cloud free. The training sites were located and ground trothed during the reconnaissance survey together with their geographic coordinates obtained using GPS.

Table 1: Details of Landsat Satellite Images

Year	Date Acquired	Sensor	Cloud cover (%)	Path	Row	Resolution
1986	19/12/1986	Landsat 5 TM	0	188	057	30m x 30m
2000	17/12/2000	Landsat 7 ETM	0	188	057	30m x 30m
2016	12/01/2016	Landsat 7 ETM	0	188	057	30m x 30m

Source: US Geological Survey, 2017

Landuse/landcover analysis and mapping

Training sites were created on each image whereby, areas with similar spectral reflectance were captured and grouped together to generate signature file for the classification. Maximum likelihood supervised classifications were performed in ERDAS IMAGINE 9.1 on the landsat images. The per-pixel supervised classifications groups satellite image pixels with the same or similar spectral reflectance features into the same information categories [5]. Three classes were discerned in this study viz.: vegetation (thick vegetation, forested lands, mangrove, sparse vegetation, farmlands and fresh water swamp); built up areas, and water bodies. The description and characterization of each of the classes is shown in Table 2. Using relevant LU/LC classes, all classes that are of interest must be cautiously chosen and defined to ensure remotely sensed data are successfully classified into land-cover or land-use information [6]. The classified landuse images were then converted to vector format to calculate the area of landuse which included the vegetal cover in each year in squared kilometers using spatial query module in ArcGIS 10.5. Areas covered by thick vegetation were separated from other landuse to generate a spatial distribution map of thick vegetative cover in Bonny Island.

Table 2: Scheme of Classification for Landuse/Landcover

S/N	Landuse/ Land cover Types	Description
1	Vegetation	Thick vegetation, Mangrove, sparse vegetation, farmland, fresh water swamp
2	Built up area	Residential, commercials and services, industrial, transportation, roads
3	Water bodies	Rivers, open water, lakes, ponds, reservoirs, etc.

Source: Researcher's Analysis, 2017

Determination of vegetation composition of Sampled Forested Areas

The vegetation make up of selected forests were observed. The study made use of three selected forests in Bonny Island whereby plants were identified and enumerated, to help us understand their floristic composition and diversity. These forests were selected because they were accessible (since there was need to identify the plants species types present in the study area). The study applied quadrat methods whereby three quadrat of 20m x 20m were laid in each sampled forest for the collection of data on the vegetal composition and the plants which included trees, shrubs, herbs, climbers, creepers and grasses were identified with the help of a Taxonomist. The data collected on the vegetation status were used to compute species composition and diversity of sampled forest in the study area.

Species Composition

Species composition of forest land was determined by counting the number of individual species in each 20m x 20m quadrat within the selected forest for the study.

Species Diversity

The species diversity index (D') was computed using Simpson's index. The formula for computing Simpson's diversity index (D) was:

$$D = \sum_{i}^{n} = 1 \frac{ni(ni-1)}{N(N-)}$$

Where, ni = the number of individuals of *ith*species

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N = the total number of individuals.

The value of D′ ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. That is, the bigger the value the lower the diversity. To remove the inverse relationship between Simpson's index and actual diversity of a community, the diversity index (D′) is subtracted from 1. The value also ranges from 0 to I but the interpretation is the higher the value, the higher the diversity and vice versa [7].

Change in Vegetation Size and Percentage change

The area in kilometer (km) of vegetation in each year was calculated and simple arithmetic was done by subtracting the area occupied by vegetation in initial year from the final year. For instance, the area in km occupied by vegetation in 1986 was subtracted from the area in km occupied by vegetation in 2000 (LU2000- LU1986). The difference gave the change in vegetation size in terms of spatial coverage (km) and direction of changes. The percentage change of the same area occupied by vegetation was then computed to determine the percentage increase or decrease of size occupied by vegetation using the formula in Equation 1. This analysis also gave an insight to understand the status of the area occupied by vegetation in each year in terms of spatial coverage in Bonny Island.

LU Initial — LU Final/LU Initial x 100

RESULTS AND DISCUSSIONS

Spatial Distribution of Land use/Land cover types in Bonny Island between 1986 and 2016

The land use/land cover types identified in the study area through the satellite images obtained for the study includes; vegetation (thick vegetation, mangrove, sparse vegetation, farmland, fresh water swamp), built up area (residential, commercial, industrial, transportation, roads), water bodies (rivers, open water, lakes, ponds, reservoir etc.) (See satellite imageries and land use analysis on Figure 3 through to Figure 8). Also, Figure 9, 10, and 11, were used to show the variation in spatial extent (size) of land use cover occupied by vegetation in Bonny Island between 1986 and 2016.

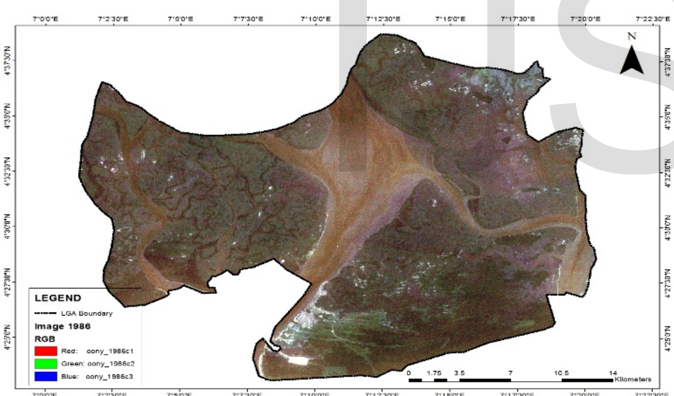

Figure 3: Satellite Image of Bonny Island in 1986

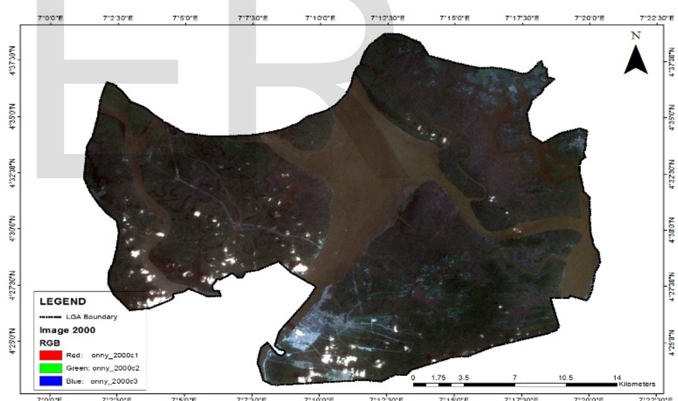

Figure 4: Satellite Image of Bonny Island in 2000

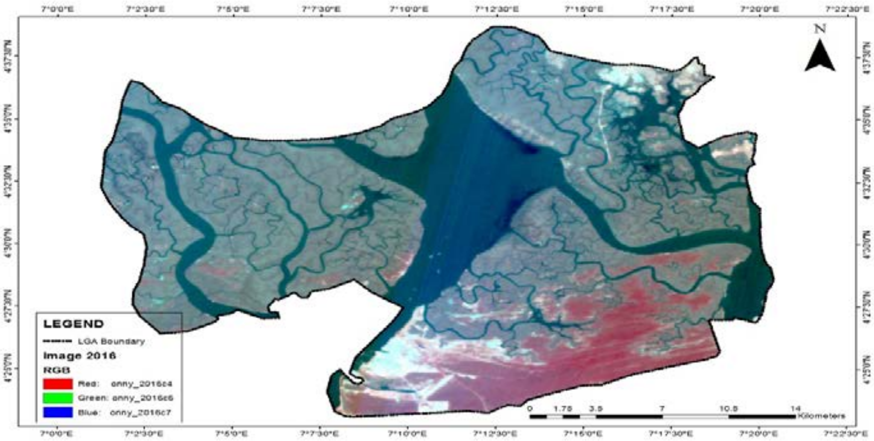

Figure 3: Satellite Image of Bonny Island in 2016

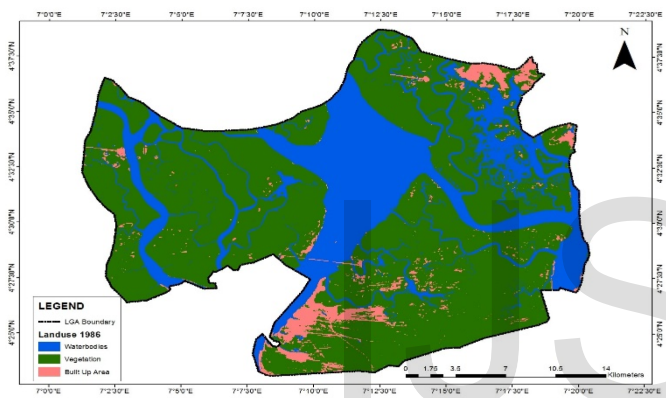

Figure 6: Land use/Land cover types in Bonny Island in 1986

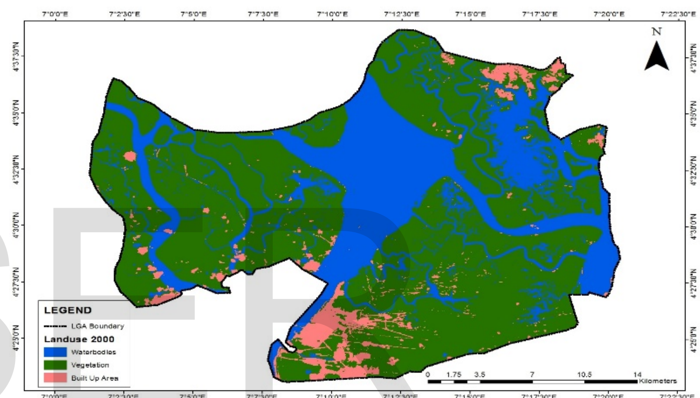

Figure 7: Land use/Land cover types in Bonny Island in 2000

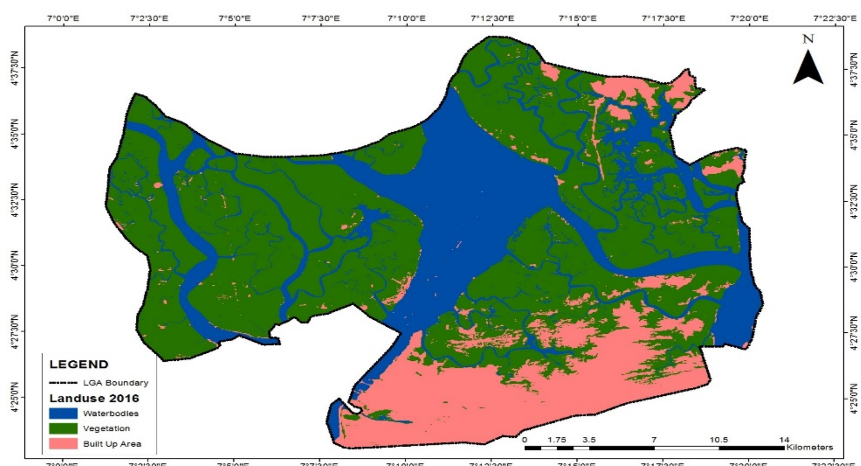

Figure 8: Land use/Land cover types in Bonny Island in 2016

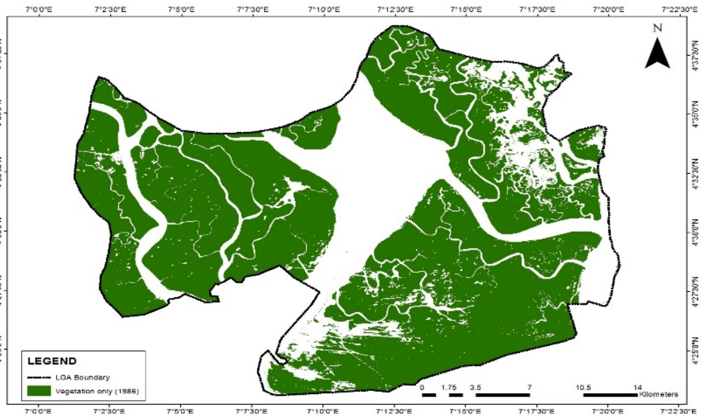

Figure 9: Vegetation Land cover in Bonny Island 1986

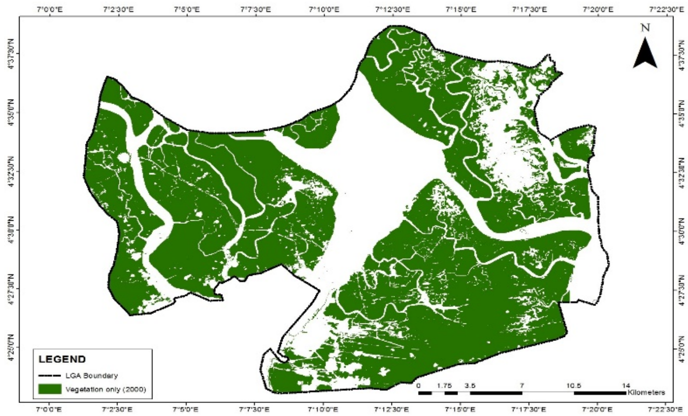

Figure 10: Vegetation Land cover in Bonny Island 2000

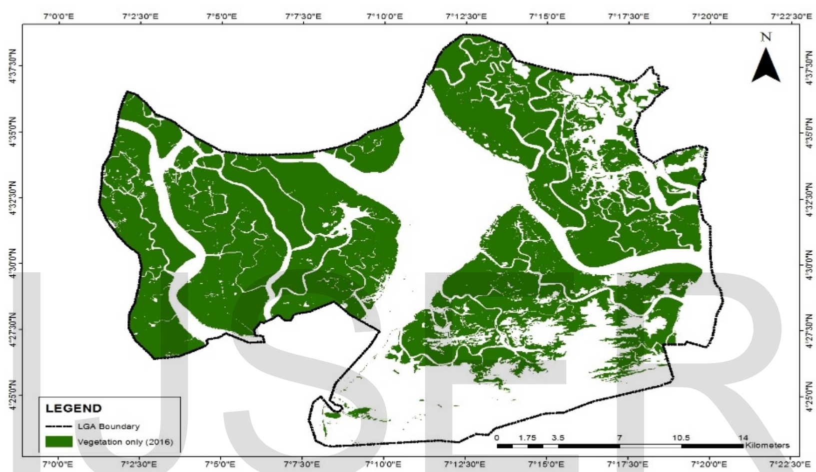

Figure 11: Vegetation Land cover in Bonny Island 2016

Periodic Changes in Land use and Vegetation Size in Bonny Island between 1986 and 2016

Table 3 showed that the year 1986 recorded 178.03 km^2 water bodies occupying about 27.81% of total land use spatial coverage. Vegetation recorded 434.10 km^2 in spatial coverage (size), about 67.34% of total land cover, while built up area, occupied 32.55 km^2 from total land area for all land use which was 644.68 km2. The year 2000 recorded a reduction in size and spatial extent of vegetation from 434.10 km^2 to 408.47 km^2. However, increase in spatial coverage of water bodies revealed a change in size from 178.03 km^2 to 197.57 km^2. The, built up area also increased from 32.55 km^{2}size to 36.64 km^2. Thus, water bodies increased or gained more spatial extent from 27.61% in 1986 to 30.65% in 2000. Consequently, the size of vegetation (spatial extent) reduced from 67.34% (which was the highest area occupied by vegetation) in 1986 to 63.36% in the year 2000 (this is a change of -3.98%). The built up area increased (due to urbanization, more lands may have been cleared) from 5.05% to 5.68% (which is a 0.63% change) from 1986 to 2000.

Table 3: Land use Spatial Pattern in Bonny in 1986, 2000, and 2016.
Source: Researcher’s Analysis 2017

Land use/Land cover	1986 (km^2)	Percentage (%)	2000 (km^2)	Percentage (%)	2016 (km^2)	Percentage (%)

Water bodies	178.03	27.61	197.57	30.65	176.94	27.45
Vegetation	**434.1**	**67.34**	**408.5**	**63.36**	**349.5**	**54.22**
Built up Area	32.55	5.05	36.64	5.68	118.22	18.34
Total	644.68	100	644.68	100	644.68	100

Furthermore, the results for the year 2016 also showed that the spatial coverage or extent of vegetation reduced, this time, a significant reduction was recorded, and it revealed a reduction in spatial extent of 408.47 km^2 to 349.52 km^2 (a total of 58.95 km^2 was lost). Water bodies reduced in spatial extent from 197.57 km^2 in 2000 to 176.94 km^2 in 2016 (a total of 20.63 km^2 was also lost). The spatial extent and size of built up area increased drastically from 36.54 km^2 in 2000 to 118.22 km^2 in 2016. That means, a total of 81.68 km^2 of spatial extent was gained. It is obvious from the explanation that the built up area increased in size at the expense of the vegetative cover and water bodies in Bonny. A change in size of built up area from 5.68% in 2000 to 18.34% in 2016 was experienced. Thus, it can be concluded that urbanization has taken its toll in the Bonny Island since the size of built up area increased from 32.55 km^2 (1986) to 36.64 km^2 (2000) and to 118.22 km^2 (2016). The spatial extent of vegetation reduced from 434.10 in 1986 to 349.52 in 2016.

The change experienced in the study area can be related to the increase in socio-economic activities of the people as a result of increase in population leading to the creation of more sub urban centre's in Bonny Island. The implication on biodiversity cannot be over emphasized, because a reduction in the size/spatial extent of vegetation means that more trees and vegetal cover have been removed due to land use change from vegetal cover to build up area.

Table 4 revealed the statistics for the percentage land use changes between 1986 and 2016. The analysis showed that vegetation cover lost 84.58 km^2 of land area about 20.33% reduction/changes in size between 1986 and 2016. The water bodies also lost 1.09 km^2 total surface areas, about 0.54% reduction in spatial extent between 2000 and 2016; even though total surface area increased by 19.54 km^2 about 10.98% change between 1986 and 2000, only to reduce to 176.94 km^2 in 2016 below its original size in 1986. However, significant changes was recorded in the size of built up area, which increased considerably by 85.67 km^2 (235.22% change) between 1986 and 2016 in Bonny Island.

Table 4: Percentage Change in Land use/Land cover in Bonny Island between 1986 and 2016

Source: Researcher's Analysis

Land use/Land Cover	**1986 (km2)**	**2000 (km2)**	**Change (km2)**	**Percentage Change**	**2000 (km2)**	**2016 (km2)**	**Change (km2)**	**Percentage Change**	**Total Change (km2)**	**Total Percentage Change (1986-2016)**
Water bodies	178.03	197.57	19.54	10.98	197.57	176.94	-20.63	-10.44	-1.09	-0.54
Vegetation	**434.1**	**408.47**	**-25.63**	**-5.9**	**408.47**	**349.52**	**-58.95**	**-14.43**	**-84.58**	**-20.33**
Built up Area	32.55	36.64	4.09	12.57	36.64	118.22	81.58	222.65	85.67	235.22

Species Composition and Diversity in Vegetative landcover

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Table 5 presents the species composition of plants, together with their common names and total number of each individual species found in the study area. The total number of species (N) found within the study area was 66 distributed into – unrelated families and also listed are the total life forms of species identified in the study area. The recorded life forms of plants species were 22 trees, 15 shrubs, 23 herbaceous plants, 5 climbers and 1 creeper plant.

The species diversity calculated in Table 6 showed that the Simpson's index of diversity (D') was 0.935 and it is tending towards 1, which means that the diversity of species identified in the study area is very high.

Table 5: Species Composition in Sampled Vegetation

S/No	Species	Family	Common Names	Local **Names**	Habit	%F (ni)
1	*Abrusprecatorius* Linn	Papilionaceae	Crab Eyes	Anya nnunu	Climber	12
2	*Acanthus montomus*(Nees) T	Acanthaceae	Mountain Thistle	Nyin-yiog-wu	Herb	14
3	*Aframomummelegueta* (Roskoe) K.Schum.)	Zingiberaceae	Guinea Grains (Grains of Paradise), Alligator pepper	Citta, Ose oji, Ata ire	Herb	8
4	*Aframomumoliveira* S.Oliveira	Zingiberaceae	Africa spice		Herb	6
5	*Ageratum conyzoides*var hirtum Lam	Asteraceae	Goat weed/Chick		Herb Shrub Tree	13
6	*Alchonealaxiflora*(Benth.) Pax & K.hoffm.	Euphorbiaceae	weed	Ububo	Shrub	21
7	*Albiziazygia*(DC.) J.F. Macbr.	Fabaceae	Senegal Rose Wood		Tree Shrub	4
8	*Alchoneacordifolia*(Schum & Thonn) Mull-Arg	Euphorbiaceae	Christmas Bush	Ububo	Tree	136
9	*Alstoniabooneii*De Wild	Apocynaceae	Stool wood		Shrub Tree	3
10	*Ancistrophyllumsecundiflorum* (P.Beauv.)	Fabaceae	Benin rattan	Dalziel	Herb	6
11	*Anthocleistavogelii*Planch	Loganiaceae	Cabbage tree	Okpokolo	Herb	22

12	*Anthonathamacrophylla (*P.Beauv.)	Fabaceae-ceasal	Oil-Palm		Tree	7
13	*AntiarisAfricana* Engl.	Moraceae	False Iroko	Bemu	Herb	8
14	*Asytasiagangetica*(L.) T. Anderson	Acanthaceae	Philippine violet		Shrub	48
					Shrub	
					Tree	
15	*Atthenantherasessilis*(L.) R.Br.	Amaranthaceae	Sessile joyweed	Guam	Herb	4
16	*Avicenniaspp* (Forssk.)	Avicenniaceae	Api-api	Ofun	Shrub	56
17	*Axonopuscompressus*(Sw.) P.Beauv.	Poaceae	Tropical carpet grass	Grass	Herb	12
					Herb	
					Climber	
					Shrub	
18	*Bambusa vulgaris*cv. Vittata	Poaceae	Bamboo	Atosi	Tree	16
19	*Baphianitida* (PROTA)	Fabaceaa	Camwood	Uri	Climbers	7
20	*Bombaxbuonopozense (*P.Beauv.)	Bombacaceae	Red Flowered Silk Cotton Tree	Runyoro	Climbers	4
21	*Bridelia patens*(Benth)	Euphoribiaceae		Agu	Herb	2
22	*Brideliaspp*Beille	Euphoribiaceae		Ola	Herb	2
23	*Centrosemapubescens*(Benth)	Caesalpinaceae	Fodder pea		Shrub	18
24	*Chromolaenaordorata* (L.) R.M. King &H.Robinson.	Asteraceae	Siam Weed	Awo-lowo	Tree	12
25	*Cissusquadrangularis*l.	Vitaceae	Eddible Steamed Vine, Devil's backbone	Daddor	Herb	6
26	*Clappertoniaficifolia* (Willd.)	Malvaceae	Hibiscus, Bolo bolo	Bolo bolo	Tree	4
27	*Cleistopholis patens*(Benth.) Engl &	Annonaceae	Salt and Oil Tree		Tree	22

	Diels				Tree	
28	*Combretummicranthum* (P.Beauv.)	Combretaceae	Christmas Rose	Alagame	Tree	10
29	*Commelinadiffusa*Burm.f.	Commenelinaceae	Climber dayflower		Creeper	2
30	*Costusafer*Ker Gawl	Costaceae	Ginger lily, Bush Cane	Okpete/ Opete	Climbers Shrub	16
31	*Cyathula prostrate* (Linn.)	Amaranthaceae	Pature weed	Kebbidoombi	Shrub	4
32	*Deinbolliapinnata*Schum.& Thonn.	Sapindaceae	Water willow	Ogiri-egba	Tree	12
33	*DracaeniamanniiBaker*	Liliaceae	Asparagus Tree		Shrub	2
34	*Elichhorniacrassipes*(Mart.) Solms	Pontederiaceae	Water Hyacinth		Herb	13
35	*Elaeisguineensis* Jacq.	Aracaceae	Africa Oil Palm		Tree	31
36	*Entandrophragmaspp*	Meliaceae	Mahogany	Ona	Tree	4
37	*Ficusexasperate* Vahl	Moraceae	Sand paper plant		Tree	7
38	*Harunganamadagascariensis* Lam ex Poir	Clusiaceae	Dragon's blood tree	Oturu	Herb	18
39	*Ipomoea aquatic* Forssk.	Convolvuaceae	Water spinach	Han Lau	Herb	4
40	*Landolphiaowariensis*(P.Beauv.)	Apocynaceae	White rubber vine	Ube	Herb	5
41	*Leeaguineensis* D.Royen ex L.	Vitaceaea	Afrikan lee		Tree	9

42	*Lonchocarpuscyanescens* Perkin	Fabaceae	Indigo vine	Talaki	Tree	3
43	*Mangiferaindica*L.	Anacardiaceae	Mango	Popo	Herb	3
44	*Militia aboensis*Wight & Arn.,				Shrub	6
45	*Musa paradisiacal L.*	Musaceae	Plantain tree	Abrika	Shrub	8
46	*Musangacecropoides* R.Br. & Tedlie	Moraceae	Umbrella tree	Okirima	Shrub	15
47	*Newbouldialaevis(*P.Beauv.)	Bignoniaceae	Africa Border tree, Fertility tree	Ogirisi	Tree	2
					Herb	
48	*Nympha palm*L.	Nymphaeceae	Mangrove palm/water coconut	osibata	Herb	44
49	*Nymphaea lotus* L.	Nymphaeceae	Egyptian water-lily	Osibata	Tree	6
50	*Palisotahirsute* (Thunb.) K. Schum.	Commelinacaea	Palisota	Ikpeleoku	Herb	9
51	*Panicum maximum* Jacq.	Poaceae	Guinea grass	Ya-kinni	Tree	19
52	*Papilionaceousspp* Giseke	Papilionaceae	Legume, Beans	Ewa	Herb	2
					Tree	
53	*Pentaclethramacrophylla* Benth.	Fabaceae	Oil bean	Ugba	Tree	4
54	*Puerariaphaseoloides*(Roxb.) Benth.	Fabaceae	Tropical Kudzu		Climber	36
55	*Rauvolfiavomitoria*Afzel.	Apocynacea	Poison' devil's pepper	Asofeyeje	Herb	11
56	*Rhizophora mangle* L.	Rhizophoraceae	Red mangrove	Tango	Herb	2

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57	*Rhizophoraracemosa*G.Mey.	Rhizophoraceae	Mangrove tree		Herb	43
58	*Senna fistula (Cassa fistula)*L.	Fabaceae	Golden Shower Tree		Herb Shrub Tree	13
59	*Sennaoccidentalis (*L.)	Fabaceae	Coffee Weed	Umuwada-nyoka	Herb	9
60	*Stachtarphetaindica* (L.)Vahl	Verbenaceae	Light-blue, snake weed		Tree	6
61	*Thymus vulguris* L.	Lumiaceae	Curry Leaf	Nch-awu	Herb	3
62	*Urenalobata*L.	Malvaceae	Caesar weed		Shrub Tree	18
63	*Vitexgrandiflolia*L.	Lamiaceae	Chastetree	Lugba	Shrub	6
64	*Vossiacuspidate* Wall. & Griff.	Poaceae	Hippo Grass		Herb	1
65	*Xylopiavillosa*Chipp	Annonaceae	Black palufon	Uda		2
66	*Zanthoxylumtessmannii*(De.Wild.) P.G. Waterman	Rutaceae	Foliage, Spice	Uzazi	Tree	4

Note: Percentage Frequency (ni) - %F(ni)

Table 6: Species Diversity in the Study area

S/No	Species	Frequency (ni)	ni-1	ni(ni-1)
1	Abrusprecatorius Linn	12	11	132
2	Acanthus montomus(Nees) T	14	13	182
3	Aframomummelegueta (Roskoe) K.Schum.)	8	7	56
4	Aframomumoliveira S.Oliveira	6	5	30
5	Ageratum conyzoidesvar hirtum Lam	13	12	156
6	Alchonealaxiflora(Benth.) Pax & K.hoffm.	21	20	420
7	Albiziazygia(DC.) J.F. Macbr.	4	3	12
8	Alchoneacordifolia(Schum & Thonn) Mull-Arg	136	135	18630
9	AlstoniabooneiDe Wild	3	2	6
10	Ancistrophyllumsecundiflorum (P.Beauv.)	6	5	30
11	AnthocleistavogeliiPlanch	22	21	462

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12	Anthonathamacrophylla (P.Beauv.)	7	6	42
13	Antiaris Africana Engl.	8	7	56
14	Asytasiagangetica(L.) T. Anderson	48	47	2256
15	Atthenanthera sessilis (L.) R.Br.	4	3	12
16	Avicenniaspp (Forssk.)	56	55	3080
17	Axonopus compressus (Sw.) P.Beauv.	12	11	132
18	Bambusa vulgariscv. Vittata	16	15	240
19	Baphianitida (PROTA)	7	6	42
20	Bombaxbuonopozense (P.Beauv.)	4	3	12
21	Bridelia patens(Benth)	2	1	2
22	BrideliasppBeille	2	1	2
23	Centrosemapubescens(Benth)	18	17	306
24	Chromolaena ordorata (L.) R.M. King &H.Robinson.	12	11	132
25	Cissusquadrangularisl.	6	5	30
26	Clappertoniaficifolia (Willd.)	4	3	12
27	Cleistopholis patens(Benth.) Engl & Diels	22	21	462
28	Combretummicranthum (P.Beauv.)	10	9	90
29	CommelinadiffusaBurm.f.	2	1	2
30	CostusaferKer Gawl	16	15	240
31	Cyathula prostrate (Linn.)	4	3	12
32	DeinbolliapinnataSchum.& Thonn.	12	11	132
33	DracaeniamanniiBaker	2	1	2
34	Elichhorniacrassipes(Mart.) Solms	13	12	156
35	Elaeisguineensis Jacq.	31	30	930
36	Entandrophragmaspp	4	3	12
37	Ficus exasperate Vahl	7	6	42
38	Harungana madagascariensis	18	17	306
39	Ipomoea aquatic Forssk.	4	3	12
40	Landolphiaowariensis (P.Beauv.)	5	4	20
41	Leea guineensis D.Royen ex L.	9	8	72
42	Lonchocarpuscyanescens Perkin	3	2	6
43	MangiferaindicaL.	3	2	6
44	Militia aboensisWight & Arn.,	6	5	30
45	Musa paradisiacal L.	8	7	56
46	Musanga cecropoides R.Br. & Tedlie	15	14	210
47	Newbouldialaevis(P.Beauv.)	2	1	2
48	Nympha palmL.	44	43	1892
49	Nymphaea lotus L.	6	5	30
50	Palisota hirsute (Thunb.) K. Schum.	9	8	72
51	Panicum maximum Jacq.	19	18	342

52	Papilionaceousspp Giseke	2	1	2
53	Pentaclethramacrophylla Benth.	4	3	12
54	Puerariaphaseoloides(Roxb.) Benth.	36	35	1260
55	RauvolfiavomitoriaAfzel.	11	10	110
56	Rhizophora mangle L.	2	1	2
57	RhizophoraracemosaG.Mey.	43	42	1806
58	Senna fistula (Cassa fistula)L.	13	12	156
59	Sennaoccidentalis (L.)	9	8	72
60	Stachtarphetaindica (L.)Vahl	6	5	30
61	Thymus vulguris L.	3	2	6
62	UrenalobataL.	18	17	306
63	Vitex grandifloliaL.	6	5	30
64	Vossiacuspidate Wall. & Griff.	1	0	0
65	XylopiavillosaChipp	2	1	2
66	Zanthoxylumtessmannii(De.Wild.) P.G. Waterman	4	3	12

Diversity = 1-D= 1-D=1-0.045 = 0.955

Source: Researcher's Fieldwork, 2017

Discussion of Findings

Study showed that vegetation size reduced from 434.10 km^2 in 1986 to 408.47 km2 in 2000 and further reduced to 349.52 km^2 in 2016. This indicates that the size of vegetation decreased in terms of spatial extent between 1986 and 2016. This suggest that the diversity of plants species have also reduced due to increased urbanization and socio-economic activities in Bonny Island between 2000 and 2016. Furthermore, this may be because population growth has forced pressure on land which in turn has exacerbated the conversion rate of vegetation. The findings are in support of Mundia and Aniya [8], whose studies revealed that the rapid changes of landuse/landcover than ever before, particularly in developing nations, are often characterized by rampant urban sprawling, land degradation

In addition, as revealed by Obiefuna *et al*. [9], population explosion has severe consequences on natural resources in the coastal terrain, water bodies, vegetal cover and wetlands inclusive. However, rapid urbanization generates hostile impacts on the ecosystem as it leads to distortions in landscape patterns, ecosystem functions and the ability to perform functions in support of human populations.

The depletion of land cover occupied by vegetation in Bonny Island has many implications on biological diversity; although, the species diversity of plants computed for sampled areas showed high diversity but the spatial extent reduced by 84.58 km^2, that is, about 20.33% has been lost to the built up area land use. Thus, several implications can be noted, which includes but not limited to depletion of mangroves, biological diversity loss, decline in the ecological services, reduction in flood retention and reduced aquifer recharge, loss of aquatic breeding grounds and a resultant loss of livelihood [9].

Stockdale [10] predicted the driving force of urbanization by bordering a forest and increase runoff volumes by 4.2 times, whereby, greater surface runoff will probably increase velocities of inflow to low lying areas and swampy lands like wetlands.

The addendum of spatial cover of built up area landuse is similar to Oladele and Oladimeji [11] whereby it was stated that the expansion towns and its accompanying activities, especially the rapid urbanization mostly emanating from developing countries, has drastically affected global land use and cover change, causing changes in the ecological processes at both local and global scales. The continuous rise in built up areas can be attributed to rural-urban migration that places a heavy demand on the environment and thus leading to urban sprawls at the city center and the suburbs [12] and these activities degrades vegetation status and causes biodiversity loss.

The built up area landuse increased in Bonny Island between 1986 and 2016 as a result of urbanization. Study revealed that built up area landuse increased from 32.55 km^2 in 1986 to 36.44 km2 in 2000 (not significant) but increased (changed) significantly to 118.22 km^2 in 2016 a total of +222.65% change, thereby affecting virgin lands and water bodies in the study area. The implication is that the spatial extent of forested areas and vegetation land cover may continue to reduce if urban sprawl continues to increase which could cause unsustainable environmental change and biological diversity decline in the Bonny Island.

The findings of this study agrees with the results of Dewan and Yamagushi [13] that monitored land-use and land-cover changes in Dhaka metropolitan, Bangladesh between 1960 and 2005, and discovered significant expansion in urban or built-up areas from 11% to 334% which is mainly attributed to the fast increase of population due to large rural-urban migration. Meyer [14] also agreed that the major threat to biological diversity comes from human activities. Agriculture, industrialization and sprawl have caused the greatest losses of vegetation cover and forested ecosystems. It is also clear from the results of the study that there is a decrease in the surface area of water bodies slightly between 2000 and 2016. The increase in spatial extent may have effect on vegetation and ecosystem functions. According to Abioye [15], the prolonged water presence creates favorable growth conditions of specially-adapted plants and promote the development of forest ecosystems and floral diversity. The quantity of water present and the timing of its presence determine the functions of an ecosystem and its role in the local environment. Thus, any impact on water bodies will directly affect ecological diversity and ecosystem functions in the study area. Several implication of the degeneration in biodiversity on man cannot be over emphasized; because higher presence of trees and shrubs in the forested lands in Bonny Island indicates that canopy structure that can moderate and prevent some environmental issues is possible by improving man's living conditions and the quality of living. Information gotten from this study has shown the high level of diverse species of plants in the sampled forest. This shows the abundance of different plant species of biodiversity in Bonny. The rich biodiversity existing in Bonny Island should be protected to ensure sustained provision of the valuable ecological resources, ecosystem functions and benefits which includes its social and economic benefits to the human populace.

Conclusion

This study has specifically revealed the diverse types of land-use and land-cover types Bonny Island and patterns of change or spatial transitions in relation to impacts on Biological diversity. The study also uncovered that the area covered by vegetation (spatial extent) has reduced greatly between 1986 and 2016. Urbanization and the upsurge in human activities as a result of oil and gas activities was discovered to may have exerted pressure on land, thereby causing loss in vegetation size overtime in Bonny Island.

Additionally, Species diversity present in the study area were identified and documented to serve as a base line for further studies and impact assessment in years to come.

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