Original Research Article

Spatial Assessment of Land use/Land Cover Dynamics From 1988 To 2018 In Bonny LGA, Rivers State, Nigeria

Abstract

This study analysed the Spatial Assessment of Land use/Land Cover Dynamics From 1988 To 2018 In Bonny LGA, Rivers State, Nigeria using Landsat imageries of 1988, 2000, 2003, 2016 and 2018 with the aid of Remote Sensing (RS) techniques and Geographic Information System (GIS). Five land use/land cover types where analysed: Waterbodies, Forest, Mangrove/Swamp, Built Up Area/Bare Surfaces and Muddy Surface. The results show that from 1988 to 2018, water bodies, forest, and mangrove/swamp reduced by 5.14%, 25.07%, and 38.28% respectively while built-up area/cleared lands and muddy surface increased by 69.42% and 682.24%. Findings show that spatial coverage of forest and mangrove/swamp decreased between 1988 and 2018 and the reduction in forest cover reduces the significant role that it plays in maintaining the ecosystem. This study has clearly shown the roles of geo-information technologies at monitoring land use/landcover change in Bonny LGA, Rivers State and therefore, recommended that re-afforestation projects, strict legislation, policies, and strategies should be established to replenish the forests and mangrove/swamp; should be put in place.

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Introduction

The demand for land is said to be increasing and for use on various means. This has led to the alteration of habitats and ecosystems. The changes in the ecosystems are a threat to biodiversity. Land cover is the earth's natural surface uninterrupted by the activities of man; including naturally occurring or man-made forest cover (vegetation) and any other evidence of land use e.g. settlement, cultivated or uncultivated land etc [1]. These land covers differ from one place to another depending on the type of activities taking place in that ecosystem. The transition or changes in land-use/cover is dynamic in nature and alters bio-physical surfaces over a period of time [2] These processes contribute to land-use change. Researches have shown that due to human activities, the earth's natural surface and man’s use of land has seriously altered the natural environment [3]. Over the years, land use and landcover has been altered due to increase in population. This increasing population requires more space for built-up (settlements) and expansion of agricultural land for the cultivation of crops and rearing of animals with other allied uses. These changes are also triggered by socio-economic factors. According to Ochege [4] the Niger Delta land use/land cover (LU/LC) is taking a positive correlation presently and causing diverse environmental challenges that require mapping. Over the last decade, the rapid growth of human population and increasing demand on land for agriculture and urbanization has led to the dilapidation of our natural vegetation [5]. The degradation of the vegetation can reduce the amount of carbon stored, hydraulic cycle and ecosystem functions. LU/LC can lead to major impacts on human welfare [6]. The study of Enaruvbe et al. [6] mentioned that LU/LC change has direct impacts on the phytodiversity, vegetation morphology, biodiversity, land degradation and climate condition of the area.

In Nigeria, forest fragmentation, deforestation of the mangrove forest and biodiversity loss occur in the Niger Delta which includes lack of protection of some areas of species richness coupled with increasing population and growth in economic activities [7]. The uncontrolled and extreme exploitation of forest resources is a socioeconomic and environmental concern [8]. Land reclamation for the building of settlements, fish farming, road construction, electricity projects, timber/fuel-wood, oil exploration/exploitation, and related activities, refuse dumping, and *Nypa furiticans* invasion are among the causes of mangrove deforestation and degradation [9]. Considering the benefits of oil exploration to the federal government, this practice has reduced agricultural activities, farming and hunting in the region [10]. This activity (deforestation) is a potential cause of species extinction in the zone [7]. Studies have shown that the Niger Delta region has different ecosystems of mangroves, freshwater swamps, and rainforest but due to human negligence and irresponsible activities, these onetime healthy systems are now defined by oil contamination of aquatic bodies and forest destruction of biodiversity [10]. Biodiversity at species level interact, this creates an unexpected response to climate change and extinction attributed to climate change involved altered species interaction. Like any other organism, a functional and productive ecosystem is fundamental for its sustainability. A good indicator of a healthy ecosystem is its richness of species diversity where high diversity has the potential to make an ecosystem functionally productive thus allowing it to be more stable and resilient. Abbas [11] who studied dynamic changes and alterations in the Niger Delta Land-use/Land-cover (LU/LC) found out that between 1986 to 2008, there was a quick and dynamic Land-use/Land-cover alteration leading to the decimation of sources of livelihood, resettlement of the people and a near of

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complete loss of biodiversity. In addition, can transform the terrestrial ecosystem goods and services can be transformed by dynamic changes associated with land-use/land-cover change and also change the presence and distribution of specific ecosystems and species.

On other studies on land-use change, different research had various findings. Riebsame, Meyer, and Turner [12] mentioned that land-use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water, and radiation budget. Mahesk [13] revealed an increase in built-up areas and bare soil at a change rate of 1.0% and 4.2% respectively, while a decrease in forest cover and low vegetation cover was observed at a rate of -2.7% and -2.6% respectively. Keenan, [14] highlighted that wetland acreage in continental United States has had a steady reduction rate primarily due to human activities and accelerated sea-level rise. A similar study conducted in Nigeria by Ayanlade et al., [15] reported that wetlands are under serious pressure and degradation. Mmom [7] highlighted that there has been a steady form of mangrove forest deforestation and biodiversity loss in the Niger Delta due to growing population, economic and social pressure where the swamps have been converted to other land uses. In the same region, Chima, and Larinde [9] also confirmed that mangrove deforestation and degradation are basically caused by land reclamation for the building of settlements, timber/fuelwood gathering and many other factors. Many studies have considered the changes in land use and land cover over different spatial and temporal scales but few have shown interest in the use of geospatial techniques especially in Bonny LGA, Nigeria. Therefore, the present study is focussing on the impacts of land use alterations and changes on biodiversity with emphasis on plants in Bonny LGA, Rivers State, Nigeria.

Materials and Methods

The study was carried out in Bonny LGA, Rivers State, Nigeria. Bonny Island is an island found in the Rivers State, Nigeria. It is 25km Southeast from Port Harcourt, the capital city of Rivers state. It is located on latitudes between 6^{o} 45’ 00’’N and 6^{o} 47’ 15’’N; and longitudes 4^{o} 41’ 32’’E and 4^{o} 43’ 30’’E (Figure 1). It has an elevation of 6.19m. Bonny LGA is bounded in the west by Degema LGA, in the north by Okrika and Ogu Bolo LGAs, in the east by Andoni LGA and in the south by the Atlantic Ocean. Bonny LGA is situated in the sub-equatorial region. The study area has a mean annual temperature of 28°C with the lowest month of not less than 25°C and the hottest at 31°C. It enjoys monsoon climate with high rainfall of about 2500 mm annually and relative humidity of about 85%. The moist southeast air blows over the region between February and November and the region receives its rain while the northeast trade wind blows over the region in the months of November through February which ushers in the dry season [16]. Bonny LGA is endowed with

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Rainforest and mangrove. Rainforest tree species include Mahogany, *Militia excelsa*, and *Triplochiton scleroxylon*. The mangrove swamp forests included *Rhizophora sp.* and *Nypa fruticans.* The topography of the area is flat terrain with very gentle slopes with an elevation less than 15m above mean sea level. The soil of Bonny LGA is predominantly sandy and also endowed with sandy beach-ridges which cause alternating lower and higher lands. The ecological zone of Bonny area is saltwater swamp and the major occupation in Andoni LGA was fishing and farming.

Image geo-processing, Land use change, and Percentage change

The study made use multi-spectral satellite images of Landsat TM 5 and OLI/ETM 8; all having some characteristics presented in Table 1. Landsat images were used because of their ability to have records of the earth's surface that are valuable and continuous in categorising analysing and monitoring changes in both the man-made environment and the physical environment [17,2]. The images were enhanced by combining all the image bands using layer stack module in Erdas Imagine 9.2 and a false colour composite image of 7, 4, and 2 was selected for each year for further studies. Band sequence 7, 4, 2 RGB is good to be used for classifying the land cover [18] and more so the band combination has the capabilities to clearly define different vegetation types. Furthermore, Enaruvbe and Atafo [6] confirmed that a combination of channel 2 (blue), channel 4 (green) and channel 5 (red) is effective in distinguishing different vegetal cover types. Information from each land cover classes was collected from extensive field survey before the classification of satellite imageries [19,6]. The field survey was performed throughout Andoni LGA of Rivers State using global positioning system (GPS). The GPS is an efficient GIS tool for data collection directly from the field which forms part of the ground-truthing [19]. The fieldwork was conducted in between December 2015 and January 2016; to tally with the season during which the imageries were obtained. A total of one hundred and ninety-three sample locations were determined within all the categories.

In this study, accuracy assessment was performed for the classified maps of 1986, 2000, and 2015. The accuracy assessment for satellite imageries is the most frequently used statistical measure of classification precision [20] and it is essentially a measure of how many ground truth pixels were classified correctly [21]. Overall accuracy, user and producer accuracy, and Kappa statistics were derived from the error matrices to find the reliability and precision of created maps. [22]. The error matrix is described as the starting point for a variety of descriptive and analytical statistical techniques for accuracy assessment [23]; and this was

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generated in Idrisi Selva software. Overall accuracy was calculated by the division of total correctly classified pixels by the total number of pixels in the error matrix [23, 6].

Typically, the Kappa coefficient is between 0 (no reduction in error) and 1 (complete reduction of error) [24].Kappa values are characterized into 3 groupings: a value greater than 0.8 (80%) represents strong agreement, a value between 0.4 and 0.8 (40% to 80%) represents moderate agreement, and a value below 0.4 (40%) represents poor agreement [23,24].

Maximum likelihood algorithm which is a supervised classification was used with the aid of a Software; Erdas Imagine 9.2 [25] was used to classify similar spectral signatures into various classes which included forest, mangrove, water bodies, built-up area, cultivated land etc. Maximum likelihood classifier was chosen because it is a widely adopted parametric classification algorithm [22]. Each land-use class area was calculated in ArcGIS 10.0 which was used to compute the land-use change and percentage change in squared kilometers. The percentage change was computed using equation (1) as given in Enaruvbe and Atedhor [6].

$$\frac{\left(\frac{d}{t1}\right) * 100}{y2 - y1} \qquad \text{.......Equ.1}$$

Where,

d: difference in the value of area covered by a land cover category at the initial time point and final time point

t_1: value of the area covered by a land cover category in the initial time point

y1 and y2: the base year and final year respectively.

The projected probability of land use changing in 10 years (2025), 20 years (2035) and 30 years (2045) was done using Markov's Transition Estimator in Idrisi Selva 17.0. The extent at which other land use types have reduced the forest land use in 2000 and 2015 was computed in ArcGIS 10.0 using an overlay method with INTERSECT operator. The INTERSECT-based overlay method gives room for the land use of a year to be overlaid on the land use of another year to

Table 1. Characteristics of Landsat Images

Year	Date Acquired	Sensor	Cloud Cover (%)	Path	Row	Resolution
1988	19/12/1988	Landsat 5 MSS	0	188	57	30m
2000	17/12/2000	Landsat 7 ETM	0	188	57	30m
2003	08/01/2003	Landsat 7 ETM	0	188	57	30m

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2016	04/01/2016	Landsat 8 OLI/TIRS	0	188	57	30m
2018	05/01/2018	Landsat 8 OLI/TIRS	0	188	57	30m

Source: US Geological Survey, 2019

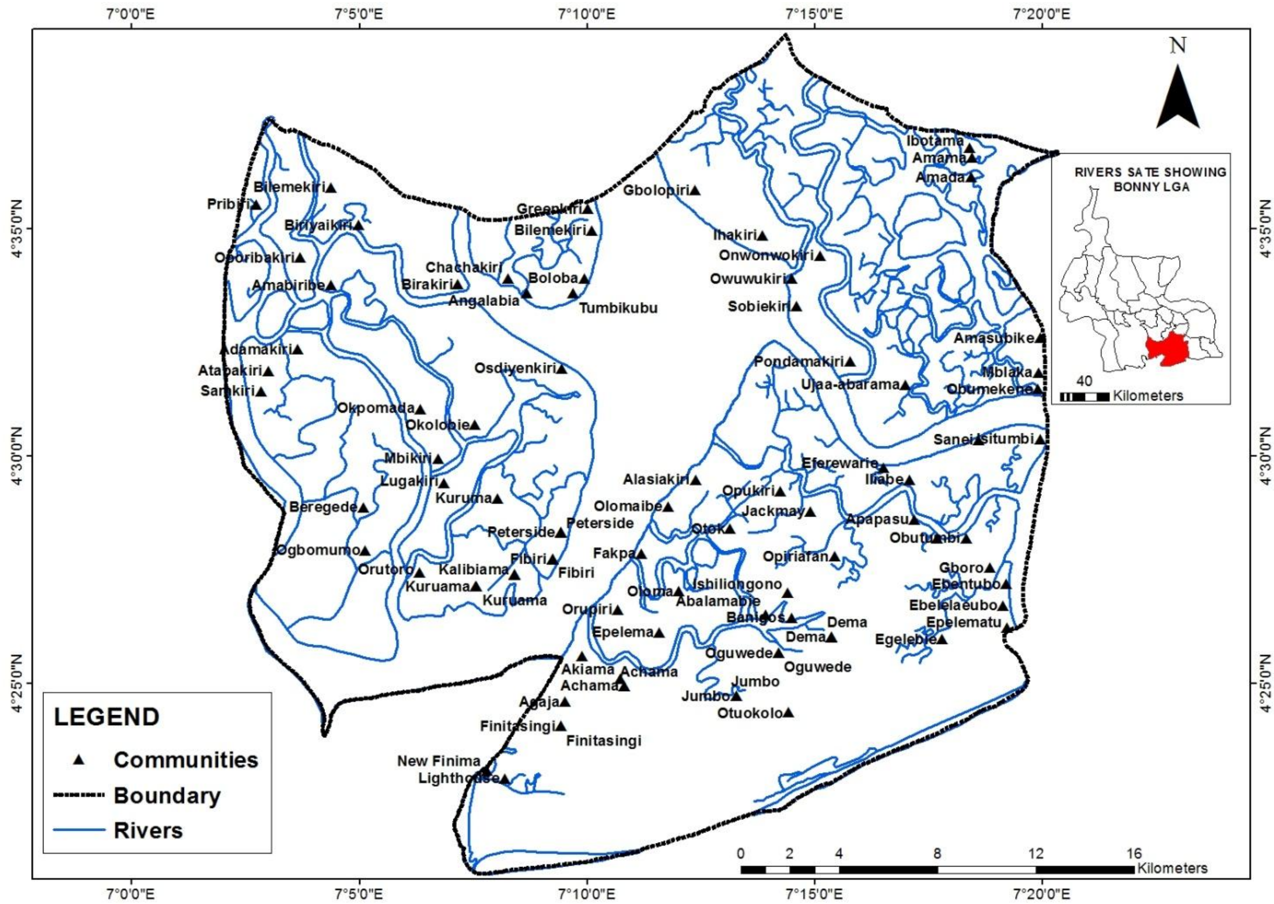

Figure 1: Bonny LGA showing communities

Results and Discussion

Land use/ Landcover patterns of Bonny LGA between 1988 and 2018

The land-use/land-cover patterns in Bonny LGA between 1988 and 2018 are presented in Table 2, Figure 2 and Figure 3. In 1988, out of the total area waterbodies covered an area of 161.98km^2 (25.22%), built-up area/cleared lands had 53.30km^2 (8.30%), forest occupied 170.41km^2 (26.54%), mangrove/swamp occupied 242.85km^2 (37.82%) while muddy surface occupied 13.12km^2 (2.04%). In 2000, the mangrove/swamp recorded 261.26 km^2 which represented 40.68% of the entire land use in Bonny LGA. However, water bodies occupied 23.53%, the built-up area occupied 19.05% while muddy surface occupied 1.89%. In the year 2003, the analysis revealed that waterbodies occupied 23.56%, while forest occupied 14.78%, and the highest was mangrove which occupied 40.88%. Similarly, in 2003, the built-up area occupied 18.98% while muddy surface occupied 1.80%. In 2016, it is shown that water bodies had 24.48% of the spatial extent in Bonny LGA while forest, mangrove/swamp, built-up area/cleared lands and muddy surfaces occupied 18.41%, 35.07%, 16.51% and 5.47% respectfully. In 2018, waterbodies had the spatial extent of 153.66km^2 (23.93%) of the total land area, forest had 127.69km^2 (19.88%), mangrove/swamp occupied 149.88km^2 (23.34%), built-up area/cleared lands occupied 90.20km^2 (14.06%) while muddy surface occupied 102.63km^2 (15.98%).

Table 2. The spatial extent of land use/land cover in Bonny LGA between 1988 and 2018

Land use/Land cover	1988		2000		2003		2016		2018	
	Areal Extent (sq km)	Percentage (%)	Areal Extent (sq km)	Percentage (%)	Areal Extent (sq km)	Percentage (%)	Areal Extent (sq km)	Percentage (%)	Areal Extent (sq km)	Percentage (%)
Waterbodies	161.98	25.22	151.11	23.53	151.32	23.56	157.19	24.48	153.66	23.93
Forest	170.41	26.54	95.30	14.84	94.88	14.78	118.21	18.41	127.69	19.88
Mangrove/Swamp	242.85	37.82	261.26	40.68	262.50	40.88	225.18	35.07	149.88	23.34
Built Up Area/Bare Surfaces	53.30	8.30	122.35	19.05	121.91	18.98	106.47	16.51	90.30	14.06
Muddy Surface	13.12	2.04	12.14	1.89	11.55	1.80	35.11	5.47	102.63	15.98
Total	642.16	100.00	642.16	100.00	642.16	100.00	642.16	100.00	642.16	100.00

Source: Researcher's analysis, 2019

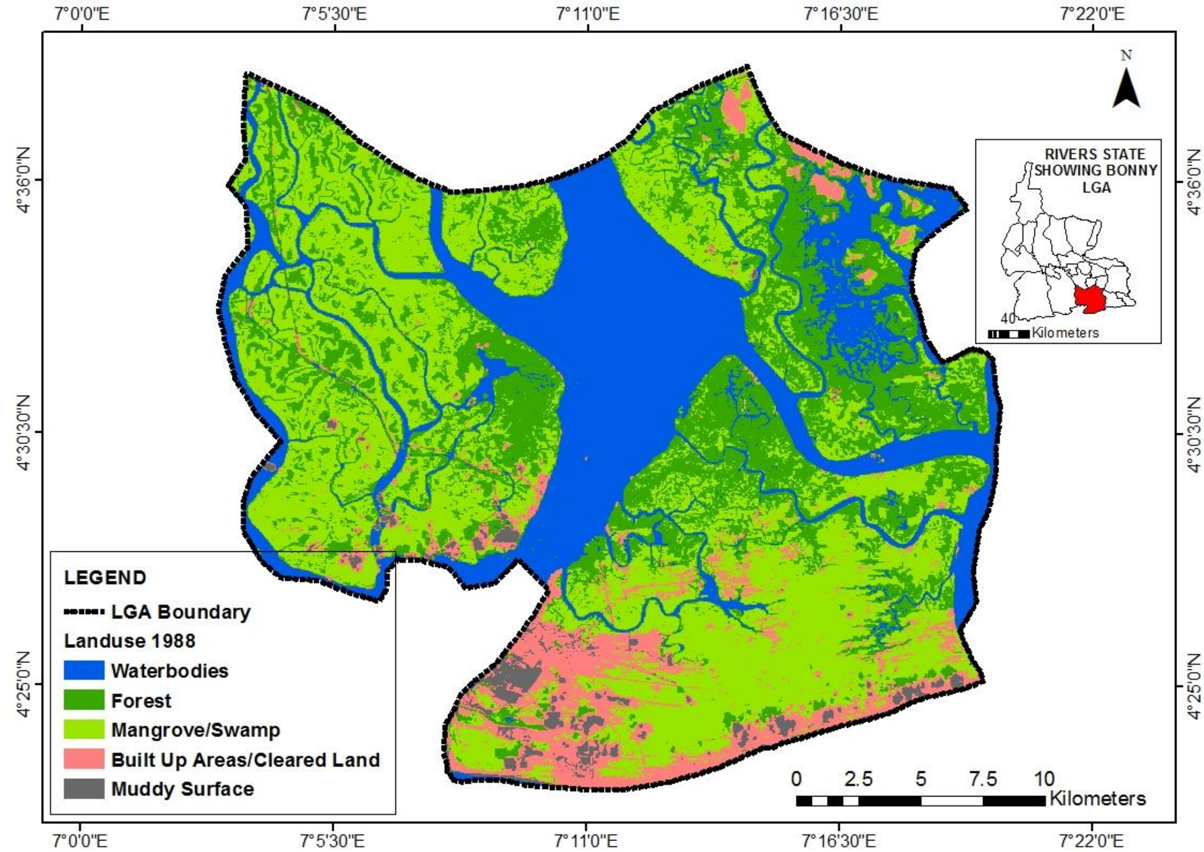

Figure 2: Land use/Landcover of Bonny LGA in 1988

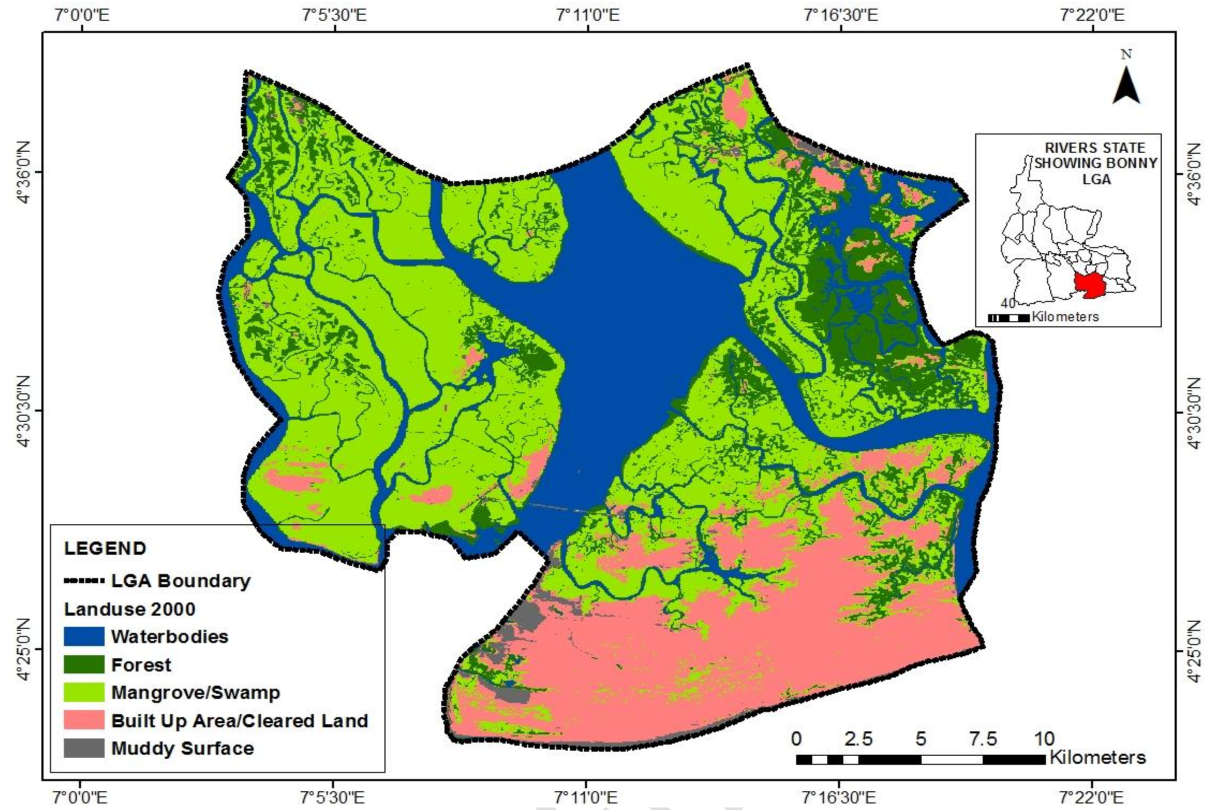

Figure 3: Land use/Landcover of Bonny LGA in 2000

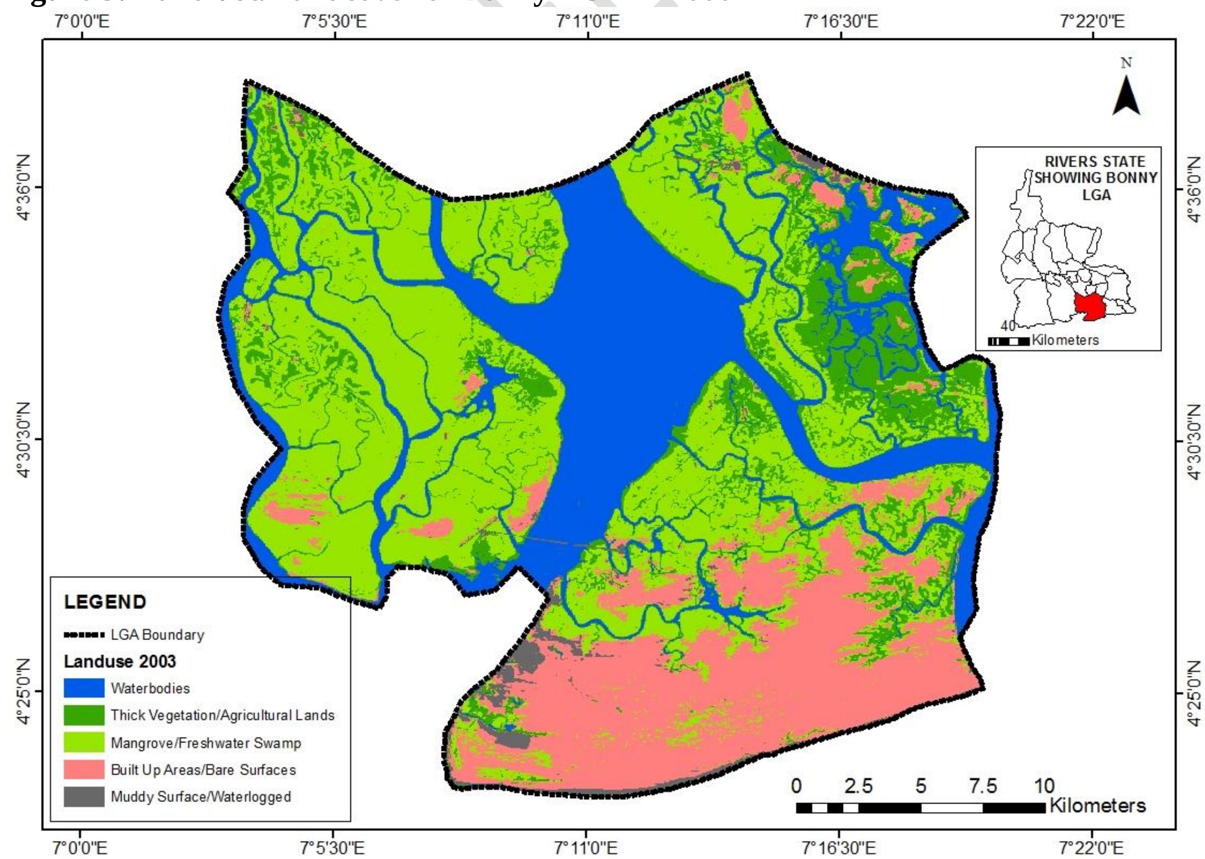

Figure 4: Land use/Landcover of Bonny LGA in 2003

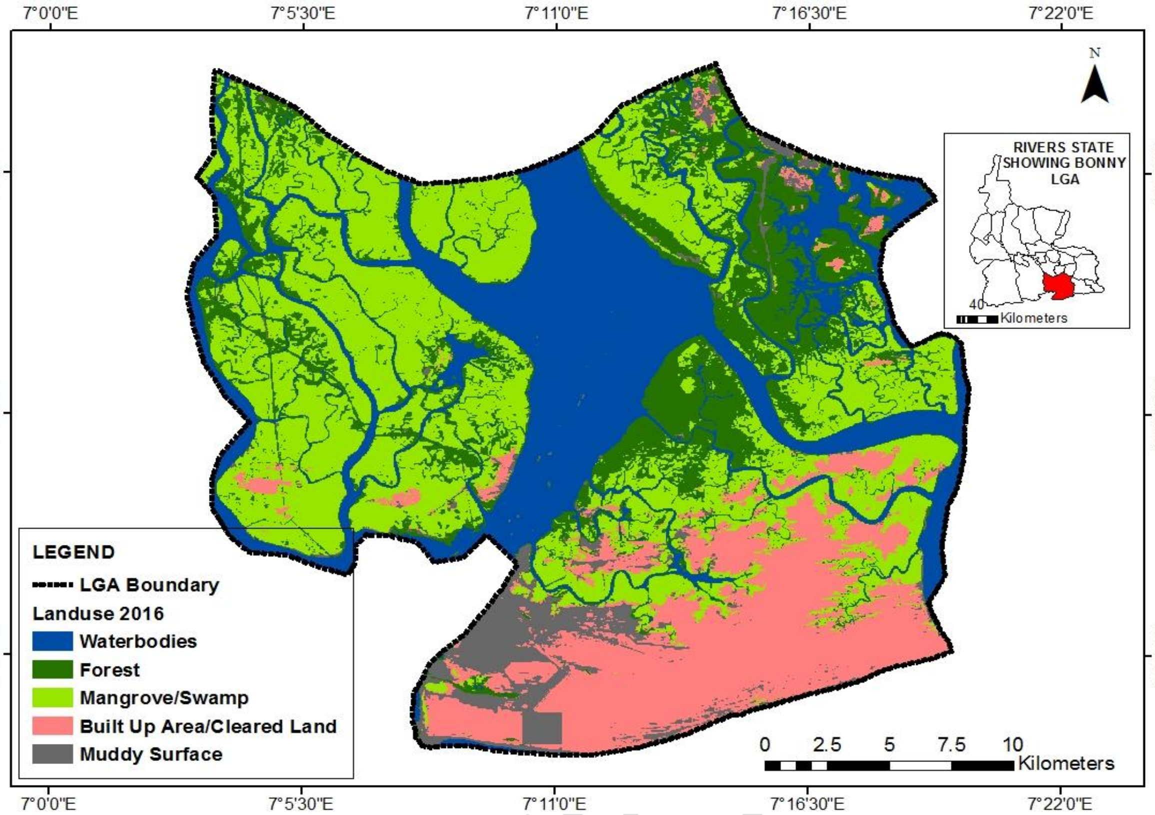

Figure 5: Land use/Landcover of Bonny LGA in 2016

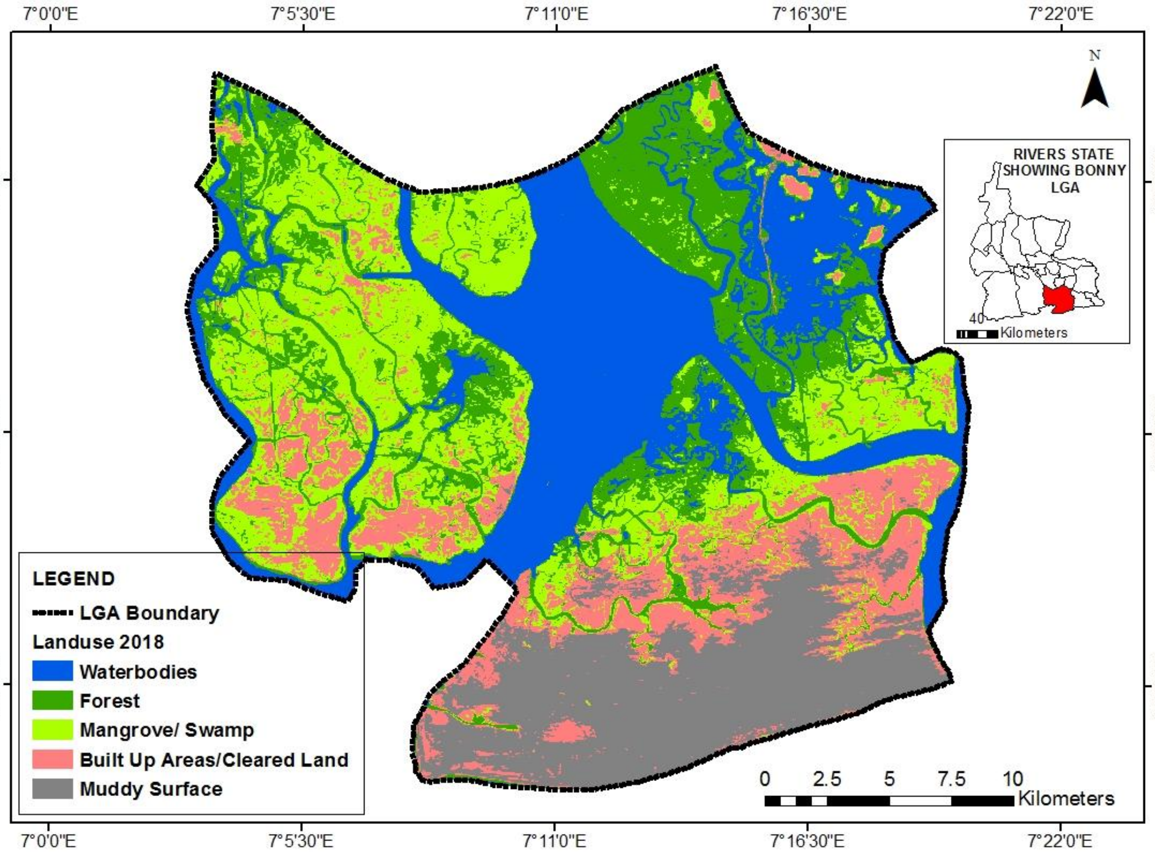

Figure 6: Land use/Landcover of Bonny LGA in 2018

Trend and magnitude of land use change and percentage change of land use in Bonny LGA between 1988 and 2018

Table 3 and Figure 6 has shown that waterbodies forest and muddy surfaces reduced by 6.7%, 44.07%, and 7.47% respectively while mangrove/swamp and built-up area/cleared lands increased by 7.58% and 129.55% respectively. From 2000 to 2003, water bodies, and mangrove/swamp increased by 0.14% and 0.47% respectively while forest, built-up area/cleared lands and muddy surface reduced by 0.44%, 0.36%, and 4.85% respectively. Between 2003 and 2016, water bodies, forest, and muddy surface increased by 3.588%, 24.59%, and 203.98% respectively while mangrove and built-up area/cleared lands reduced by 14.22% and 12.67% respectively. Furthermore, between 2016 and 2018, water bodies, mangrove, and built-up area reduced by 2.25%, 33.44%, and 15.19% respectively while forest and muddy surface increased by 8.02% and 192.31% respectively.

Generally, from 1988 to 2018, water bodies, forest, and mangrove/swamp reduced by 5.14%, 25.07%, and 38.28% respectively while built-up area/cleared lands and muddy surface increased by 69.42% and 682.24% (Table 3; Figure 7).

Table 3. Trend and magnitude of land use change and percentage change in Bonny LGA between 1988 and 2018

Land use/Land cover	1988-2000		2000-2003		2003-2016		2016-2018	
	Trend/Magnitude of land use change (km^2)	Percentage change (%)	Trend/Magnitude of land use change (km^2)	Percentage change (%)	Trend/Magnitude of land use change (km^2)	Percentage change (%)	Trend/Magnitude of land use change (km^2)	Percentage change (%)
Waterbodies	-10.87	-6.71	+0.21	0.14	+5.87	3.88	-3.53	-2.25
Forest	-75.11	-44.07	-0.42	-0.44	+23.33	24.58	9.48	8.02
Mangrove/Swamp	+18.41	7.58	+1.24	0.47	-37.32	-14.22	-75.3	-33.43
Built Up Area/Cleared Land	+69.05	129.54	-0.44	-0.36	-15.44	-12.66	-16.17	-15.18
Muddy Surface	-0.98	-7.47	-0.59	-4.86	23.56	203.98	67.52	192.30

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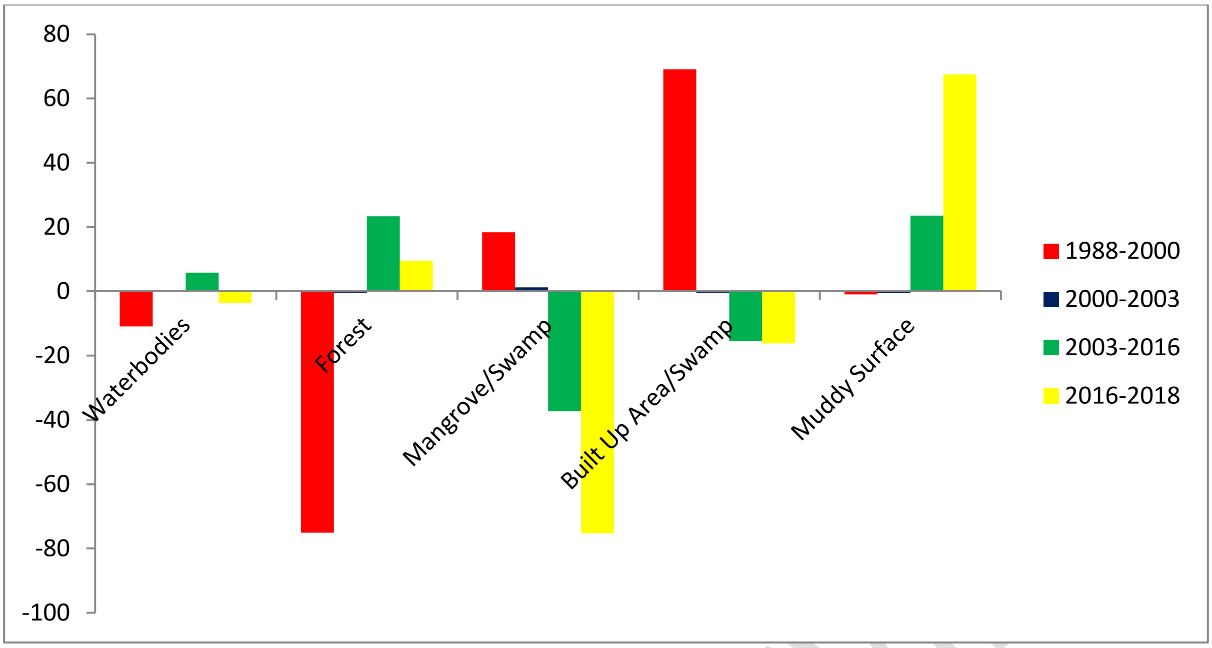

Figure 7. Periodical Trend of Land use Change between 1988 and 2018

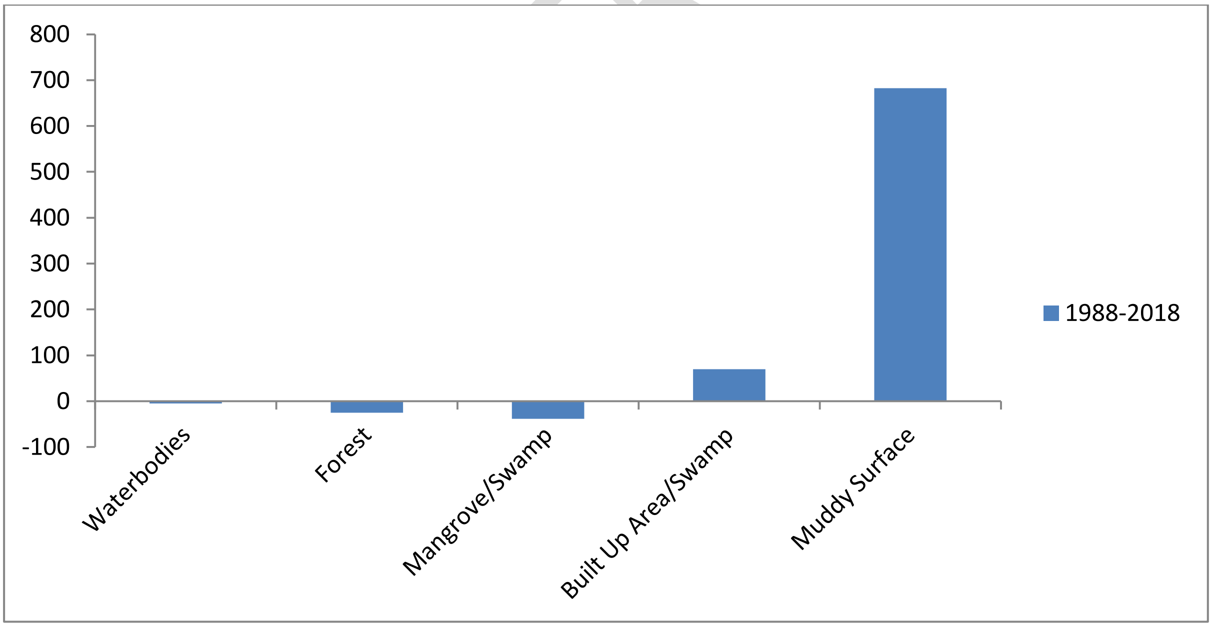

Figure 8. General Trend of Land use Change between 1988 and 2018

Discussions

Findings show that spatial coverage of forest and mangrove/swamp decreased between 1988 and 2018 and this shows that forest land is often tampered with over the years by other land use. The findings are in agreement with Gessesse (21) and Egwuogu *et al.* [26] whose studies revealed that forest cover changes from time to time because of population growth, urbanization, industrialization, and other forms of exploitation. Fabiyi (27) believed that human activities comprising of consumption of biomass fuel, land-use changes and agricultural activity have a direct relationship with land surface and detrimental effects on vegetation and environmental quality. [27]. Similarly, Johnson *et al*. [28] further stated that non-forested vegetation and coastal wetlands are paramount receptors of the adverse and dynamic landscape alteration and changes as a result of increasing urban development. Adoki [29] also noted that several forces over the years especially oil and gas exploitation/exploration and development of urban settlements have imprinted indelibly on the Niger Delta which is found in the fragile ecosystem.

The reduction in forest cover reduces the significant role that it plays in maintaining the ecosystem. Efiong [30] reported that forest removal is a factor that enhances global warming that is threatening the environment as the role of plants in carbon sequestration and reduction of CO_2 concentration in the atmosphere has been defeated. The decrease of forest cover in this study area is an epitome of regional or global forest cover change over a period of time amidst varying reasons which was also reported in Keenan *et al.* [14].

The reduction in the waterbody and increase in the built-up area/cleared land is comparable to the work of Suleiman *et al*. [31] which reported that anthropogenic activities like exploitation of resources and development of built-up area have an immensely negative effect on vegetation and water bodies. The increase in the built-up area/cleared over time may be attributed to the reduction in forest cover for infrastructural development in the built-up area. With the reduction in the water bodies, forest and mangrove/swamp, the natural habitat of wild animals and plants have been distorted and biodiversity in these places would have been displaced or reduced with respect to their composition.

Conclusion and Recommendations

The study has shown the roles of geo-information technologies in monitoring land use/land cover change in Bonny LGA, Rivers State, Nigeria between 1988 and 2018. This study has clearly revealed that population growth and construction/infrastructure are observed to be major drivers of land use change and need to be monitored frequently to ensure biodiversity of an ecological sensitive region does not deplete. The reduction of water bodies, forest, and mangrove/swamp over time is an indicator that biodiversity loss is imminent. The study, therefore, recommends that re-afforestation projects, strict legislation, policies, and strategies should be established to replenish the forests and mangrove/swamp; and the establishment of forest reserves should be encouraged.

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