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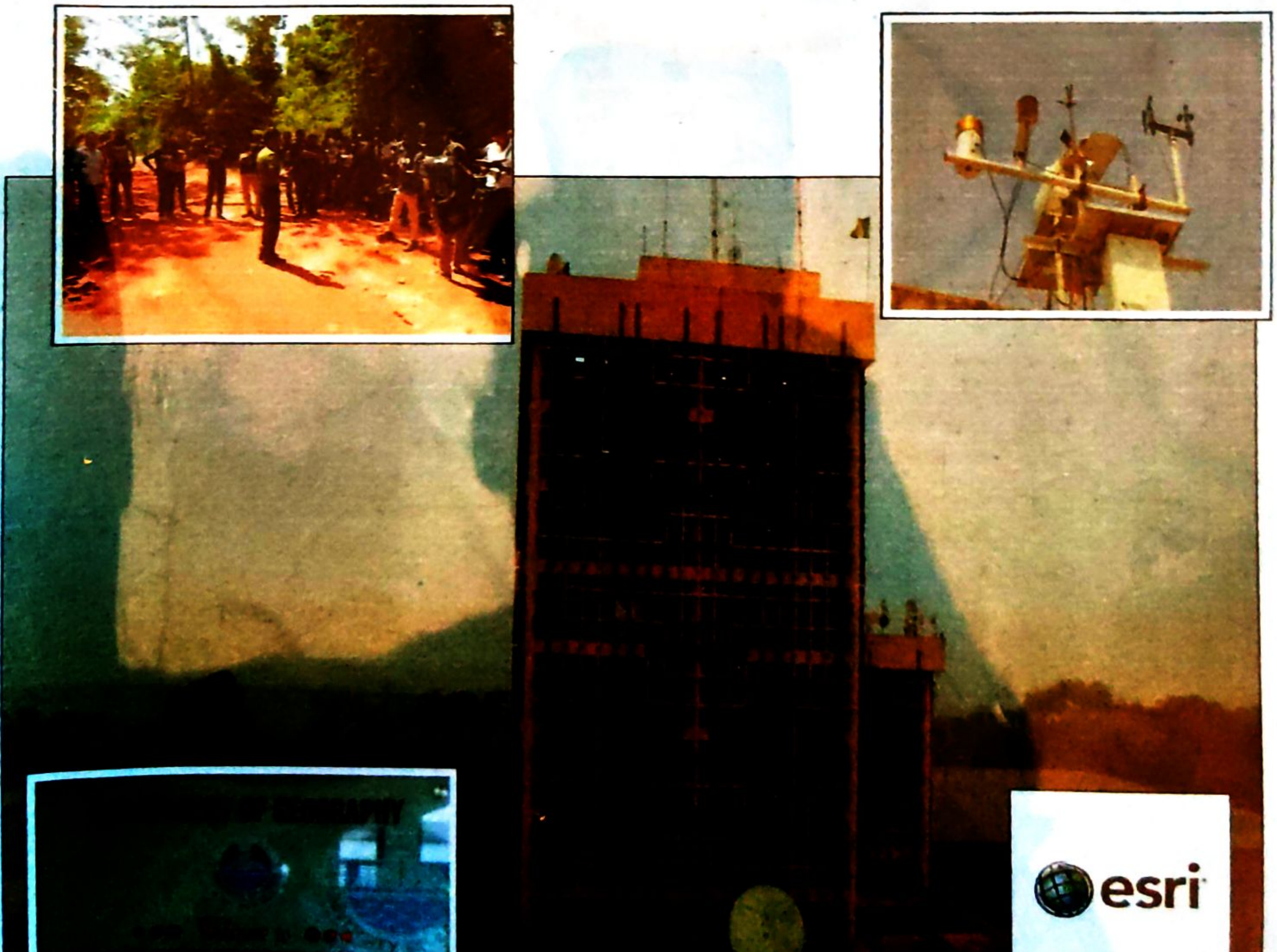

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THE GEOGRAPHICAL PERSPECTIVES

An Assessment of the Dynamics of Flora within Borgu Sector of Kainji Lake National Park (KLNP), Nigeria[1]

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Abstract

Increase in human population has brought about high demands for natural resources for human sustainability which constitute a growing threat to the physical integrity, richness, biodiversity productivity of woodland in Borgu sector of the park. In assessing the dynamics of flora within the park, Landsat imagery of the study area was acquired, using bands 4, 3, and 2, a false colour composite for 1994, 2004 and 2014 was produced. Land use Land Cover classification of the multispectral imagery was done using the supervised classification. Five (5) main classes namely; Forestland, Grassland, Wetland, Water body and Built up were identified using the Idrisi software. The Normalized Difference Vegetation Index (NDVI) was performed to assess the greenness and this was generated using the near infrared and red bands formulae for NDVI. The result showed difference in the spectral response of various land cover types existing in and around the park with high human activities encroaching the park premises. The analysis also showed a linear relationship between the vegetation of woodland and grassland. That is, as the woodland is declining, the grassland is increasing in area due to human activities. The bird eye view of the study area by remote sensing has proved very useful during this research and calls for the attention of the management, and the need to sensitize the villagers around the park to avoid and mitigate continuity of human activity at the fringe of the park reserve to save the ecosystem from destruction and interference.

Keywords; Assessment, Flora, dynamics, Park

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Introduction

The establishment of protected areas (PAs) is one of the main tools used to reduce and prevent habitat loss, fragmentation, and the resultant decline and loss of wild populations of plants and animals. PAs have two main roles: to encompass a representative sample of the biodiversity of the regions in which they are located; and to buffer biodiversity from threats to its persistence. Threats to habitat integrity can be direct, such as the conversion of natural and semi-natural ecosystems to farmlands or other land uses, or they can be indirect, such as pollution or the introduction of invasive non-native species Swanni, *et al* (2015). Conservation has often been thought of as a protective 'locking away, of resources by a power elite who has the time to enjoy the beauty of nature, as essentially selfish and anti-development activity. However, protected areas, when designed and managed appropriately, are recognized as offering major sustainable benefit to society. Traditionally viewed as National parks, Nature Reserves and Protected landscapes, the term "Protected Area" today encompasses more recent approach such as sustainable use of resources and wilderness areas. The world conservation union International Union for Conservation of Nature (IUCN) defines a protected area as "an area of land or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (IUCN, 2000).

Although many protected areas are set up by governments, others are increasingly established by local communities, indigenous peoples, environmental charities, private individuals, companies and others. There is a huge and growing interest in the natural world, and protected areas provide us with opportunities to interact with nature in a way that is increasingly difficult elsewhere. They give us space that is otherwise lacking in an increasingly managed and crowded planet. Protected areas also represent a commitment to future generations (Marguba, 2002). Many of the world's wild plant and animal species do not have viable populations in protected areas and a substantial proportion remain completely outside protected areas (Rodrigues *et al.* 2004).

Nigeria's natural ecosystems are highly vulnerable to many undesirable influences, deliberate or unintentionally attributed to different anthropogenic activities. They are increasingly coming under pressure from excessive human activities such as hunting, overgrazing, logging, slash and burn agriculture, shifting cultivation, etc. which are some of the problems faced by the Borgu sector of Kainji Lake National Park (KLNP). Increase in human population has created large concentration of human activities around the park with high demand for natural resources. Increased reliance on floral diversity services for energy, food, and other product for human sustainability constitute a growing threat to the physical integrity, richness, biodiversity productivity of woodland in the park. All of these should not be underrated as their devastation of the natural environment can be costly, socially, ecologically and financially.

Kainji Lake National Park (KLNP), despite its legal status, designation as protected areas does not in itself guarantee protection of the ecosystem they contain. According to Clark *et al.*

(2008), whilst protected areas generally reduce deforestation relative to unprotected areas, they do not entirely eliminate land use change within them. The paper aims at assessing the dynamics of flora within the Borgu sector of KLNP using Remote Sensing Techniques.

The potential of satellite data of different spatial and temporal resolutions in generating inputs for assessing the biodiversity cannot be over emphasized. Over the past few years, global datasets from coarse spatial resolution sensors have become more and more readily available. According to Townsend *et. al.* (1994), use of satellite image data for mapping and monitoring global land-cover, biomass burning, estimating geophysical and biophysical characteristics of terrain features, or monitoring continental-scale climate shift, is a primary input for flora diversity assessment. An interesting review of several experiences, conducted at a large scale, nationally and sub-continentally and using long time series of satellite derived NDVI as the basis for assessment, can be found in the work of (Gibson, 2006.). For example, relevant studies using long-term satellite derived NDVI as an indicator of land degradation have been done in West Africa (Herrmann, *et. al.*, 2005; Olsson, *et.al.* 2005) and in the Eastern Mediterranean region but little has been done to assess the dynamic of flora within the study area using the adopted technique.

The Study Area

Kainji Lake is Nigeria's first experiment at establishing and managing a National park. The Park has a total area of 5340.82 sq. km out of which Borgu sector alone accounts for 3,970km^2 which is about 74.3% of the total land area, and is located in the northwest central part of Nigeria. The park is located between latitudes 9°40'N to 10°30'N and longitudes 4°30'E to 5°50'E. It enjoys savanna climate of Nigeria with two distinct seasons of wet and dry seasons. The mean temperature during the wet season is about 30°C and drops to about 28° C during the dry season being affected by the north east harmatan winds. Rainfall is a major climatic element in the park being responsible for vegetal growth and the hydrology of the rivers. The mean annuals rainfall is about 1200mm. The rainfall amount increases to the southeast from Borgu towards the Niger valley. This is due to leeward nature of the park site being east of the Yoruba hills.

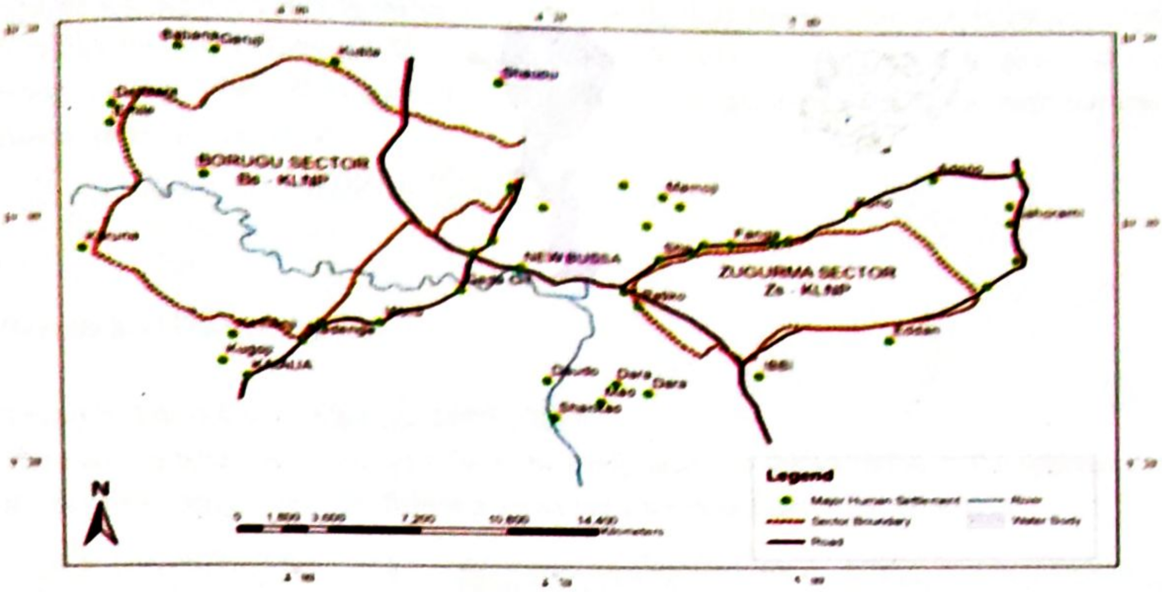


Figure 1: KLNP- two non contiguous sectors with surrounding Communities.

Borgu sector is well drained by River Oli and Eri. River Oli, the main river of the Borgu sector takes its source from outside Nigeria and drains the western two-third of the park. While river Eri drains the remaining northern one –third of the sector. The topography consists of hills, extensive plains and river valleys. On the whole, the entire area is gently undulating with quartzite ridge in few places. Elevation in most parts of the park ranges between 250m and 300m. The highest point in the park is at the northwestern corner with an elevation of 350m, while the lowest elevation is along the River Niger where the maximum water mark is about 140m.

Methodology

Satellite Image analysis

Landsat imagery was acquired and bands sequence of 4, 3, and 2 was used to produce a false colour composite for the year 1995 2005 and 2014. For Land use Land Cover classification of the multispectral imagery, from which the study area was subset and classified using the supervised classification, five (5) main classes namely; Forestland/woodland, Grassland, Wetland, Water body and Built – up/Roads were identified in the area using the Idrisi software . Training sites or classes of pixels for Area of Interest (AOIs) were selected as representative area for each identified class. Supervised classification techniques of maximum likelihood were used because it assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. The Idrisi software offers 19 vegetation Index models grouped into slope based and distance based models. Since it is apparent that soil influence is mostly visible in all the indexes, the research carefully studied and chose the model that best reduced the influence of soil considering the fact that the Landsat images are acquired in December when the biomass is less and the soil influence is maximum. The Normalized Difference Vegetation Index (NDVI) was performed to assess the greenness using Landsat 1995, 2005 and 2014. The NDVI was generated using the near infrared and red bands formulae for NDVI

$$NDVI = \frac{NIR-RED}{NIR+RED}$$

Results and Discussion

Trend in Land Cover Change 1995 - 2014

The trend in land cover change within the study area and the variation in the spectral response of the satellite imagery for the different years are shown in figures 2a, 2b and 2c

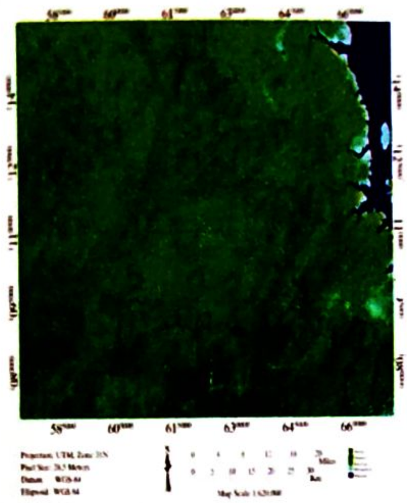


Figure 2a

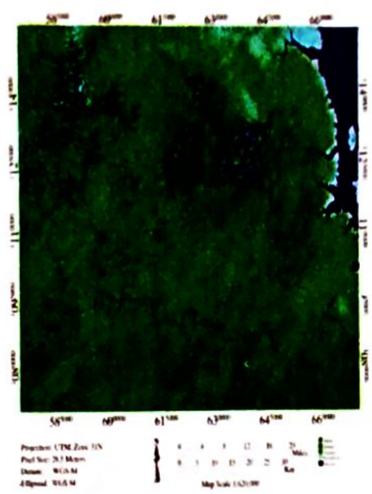


figure 2b

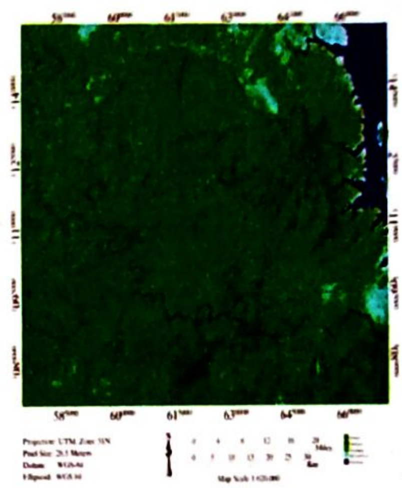


figure 2c

Figure 2a, 2b and 2c: Classified Landsat TM imagery of 1995, 2005 and Landsat ETM+ 2014

The classified image shows that the Park is mostly covered by woodland taking about 40.4% (see figure 2a) of the total area (that is about 1588 $km^{2)}$. The woodland covers the center of the Park with few built up towards the south eastern and north eastern part of the Park. The Land cover change for the year 2005 shows a significant increase in the built up area in the surrounding communities of Wawa, to the east of the Park, Luma to the north and Garuji which is to the North West of the Park by about 2.71%. Image difference has been applied to assess the trend in land cover changes between the years. The result shows difference in the spectral response of various land cover types existing in and around the park. A high level of human activity, precisely agriculture and deforestation are encroaching and engulfing the park premises. The profiles of the changes that occur over the time period are presented in the following sections.

Percentage Land Cover Change of 1995 -2014 Satellite Imagery

The percentage land area change derived from the satellite imagery for the year 1995, 2005 and 2014 is as presented in figure 3a, b and c.

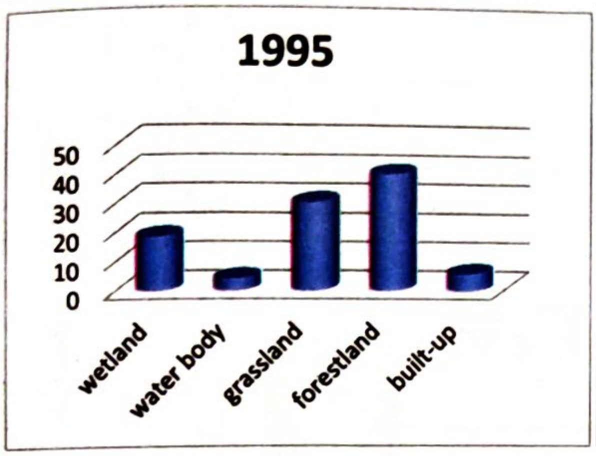


Figure 3a

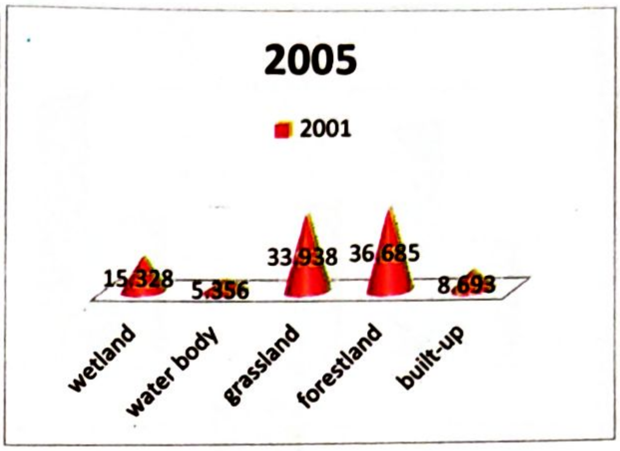


Figure 3b

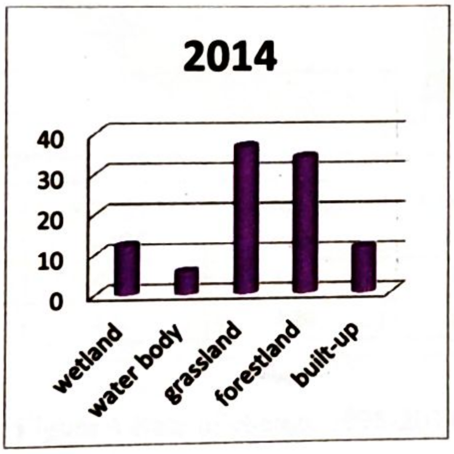


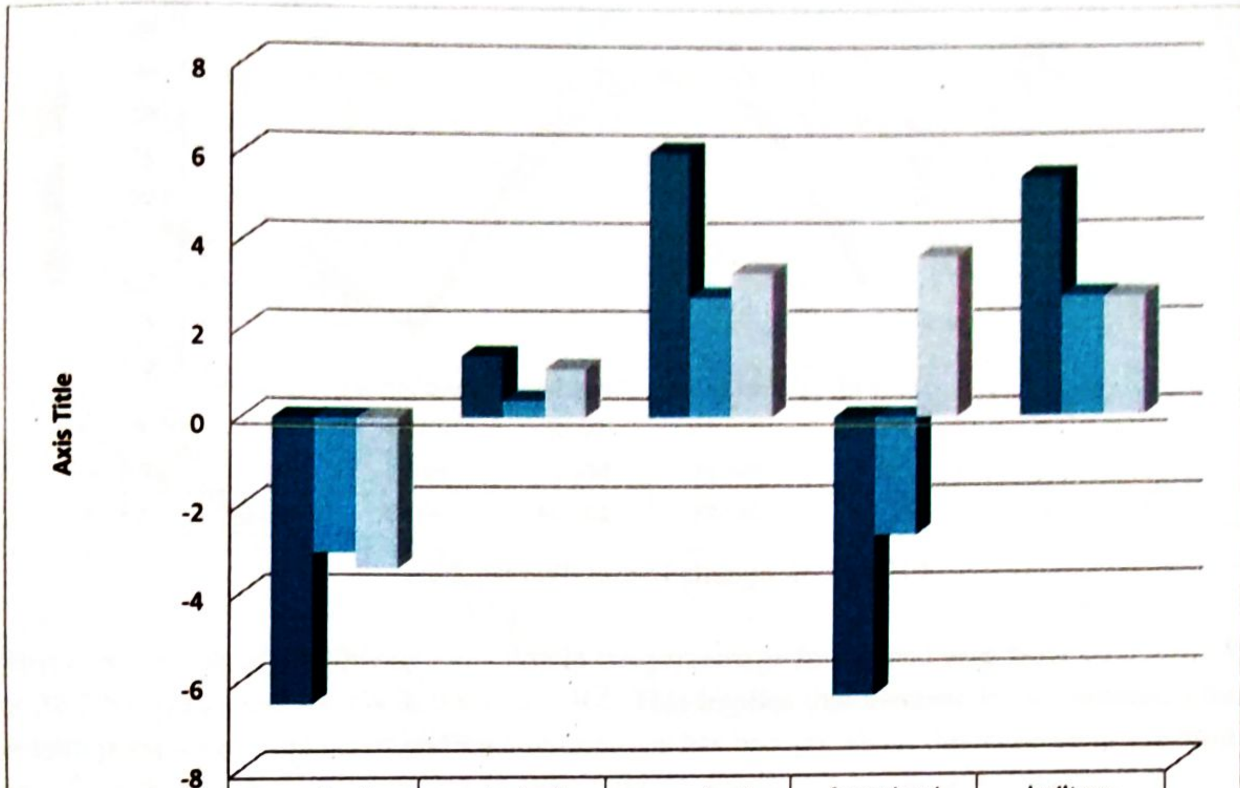
Figure 3c

Figure: 3a, 3b and 3c percentage area of classified 1995, 2005and 2014 satellite imagery.

The classified satellite imagery gave the different classes as having the following values, with wetland covering about 18.76% of the total area, water body 4.25%, and grassland 30.66%, while forestland takes about 40.35% and built up 5.98%. The percentage land cover change for the years under study is presented in figure 3a, 3b and 3c and this has shown significant variations between the years under review; that is 1995 2005 and 2014 respectively with an increase in the built up, grassland class, and a decrease in the forest or wood land class.

Percentage land cover change of the different classes

From figure 4, changes have varied by years; there was a temporal variation between 1995 and 2014



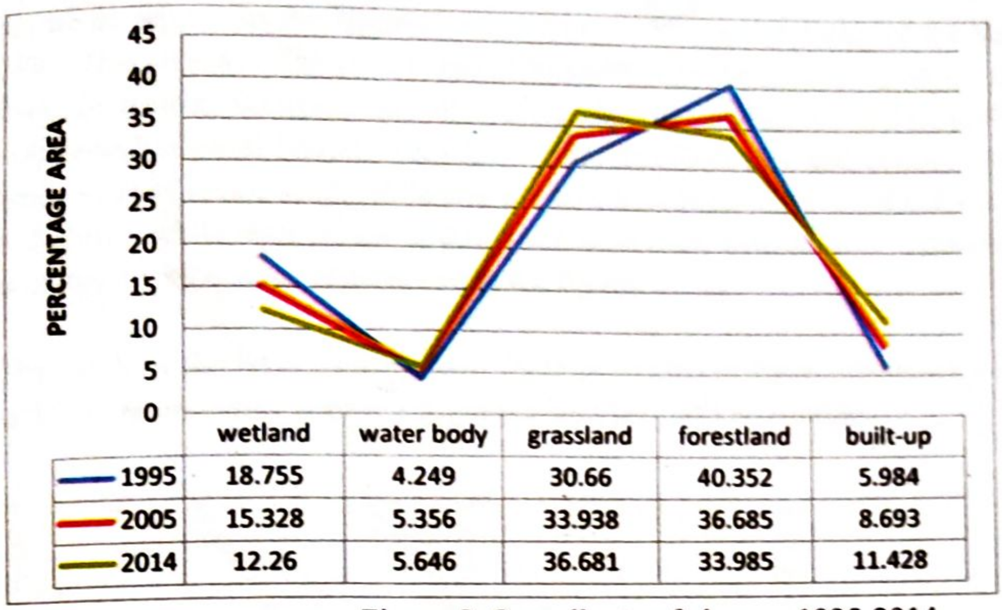
	wetland	water body	grassland	forestland	built-up
2014 - 1995	-6.495	1.397	6.03	-6.36	5.45
2014- 2005	-3.07	0.39	2.74	-2.7	2.74
2005-1995	-3.43	1.11	3.28	3.66	2.71

Figure 4 Rate of change 1995-2014

It shows a significant decrease in the wetland by about 6.5%, grassland has increased by 6.0%, a reduction in the area of forestland by 6.5% and built-up has shoot up by 5.5 %. The removal of trees brings about the degradation of land and this ultimately reduces the diversity of flora as observed in the study area.

Class Distributions of Land Cover in the Study Area

There has been a reduction in the percentage of wetland from 18.8% in 1986 to 15.3% and 12.3% in the years 2005 and 2014 respectively as shown in figure 5. Grassland has continued to increase from 30.6%, 33.9 and 36.7% for the years 1995, 2005, and 2014 respectively.



	wetland	water body	grassland	forestland	built-up
1995	18.755	4.249	30.66	40.352	5.984
2005	15.328	5.356	33.938	36.685	8.693
2014	12.26	5.646	36.681	33.985	11.428

Figure 5. Overall rate of change, 1995-2014

This is as a result of continuous reduction in the percentage forest land area from 40.4% in 1995, to 36.7% in 2005 and 34.0% in the year 2014. This implies that increase in the concentration of human population in the surrounding communities has brought about the increase in the built-up area from 5.98% in 1995 to 8.7% in 2005 and 11.4% in 2014. The assessment of the multi-temporal satellite data revealed the trend in the vegetation status existing within the park as most of the degradation of vegetal cover is occurring at the fringe of the park area due to the increasing dependence on the natural resources.

Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index performed to ascertain the level of floral degradation within the park is shown in figures 6a, 6b and 6c.

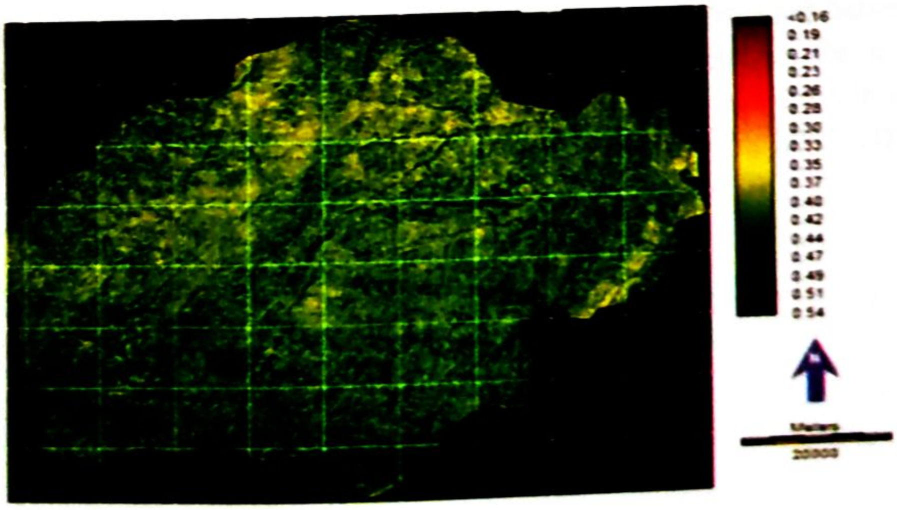


Figure 6a; NDVI Map of Landsat 1995

Figure 6a represents the Normalized Difference Vegetation Index of the study area for the year 1995. This shows a high percentage of biomass with the greener areas having a value of 0.35 to 0.49. In general interpretation of NDVI, Negative values of NDVI (values approaching -1) correspond to water bodies. Very low values of NDVI (0.1 and below) generally correspond to bare areas of rocks, sand, while low positive to moderate values of 0.2 - 0.3 represent grassland and shrubs while high values of 0.6 to 0.8 is an indication of high vegetation indicating tropical rain forest which is not represented in the figure.

The result of the NDVI for the year 2005 presented in figure 6b shows value of between -0.21 and 0.31 representing between degraded land/bare soil and shrubs.

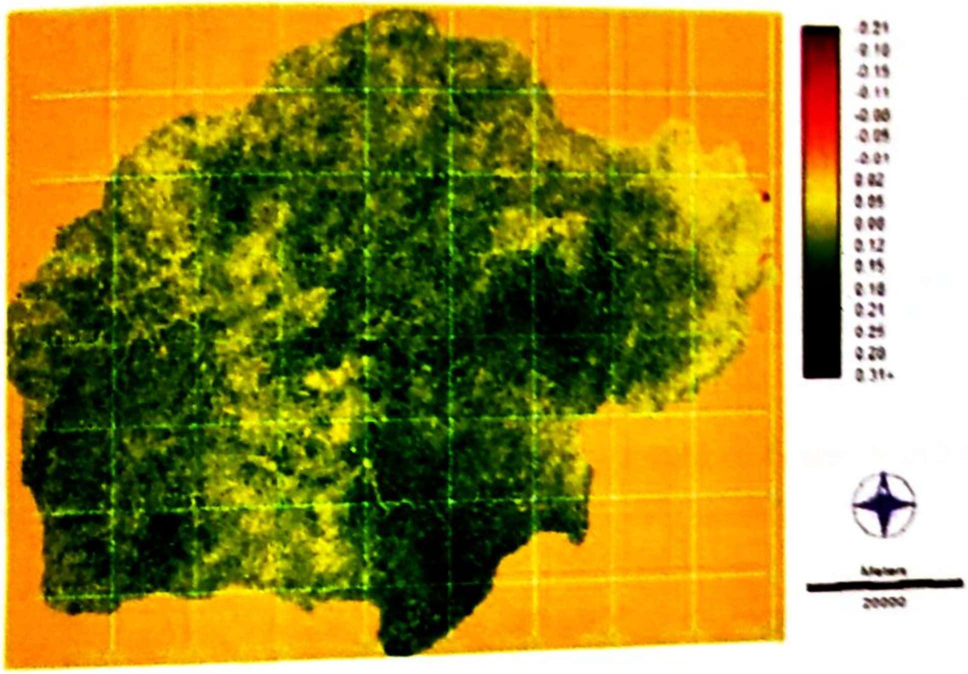


Figure 6b; NDVI Map 2005

This implies that a large area of the park has been degraded between the year 1995 (figure 2a) and 2005 (figure 2b) when compared with a reduction in the image values. While figure 6c presents the NDVI result for the year 2014 showing a reduction in the amount of vegetal cover in the study area if compared with the values obtained in the 2005 NDVI image (figure 6b).

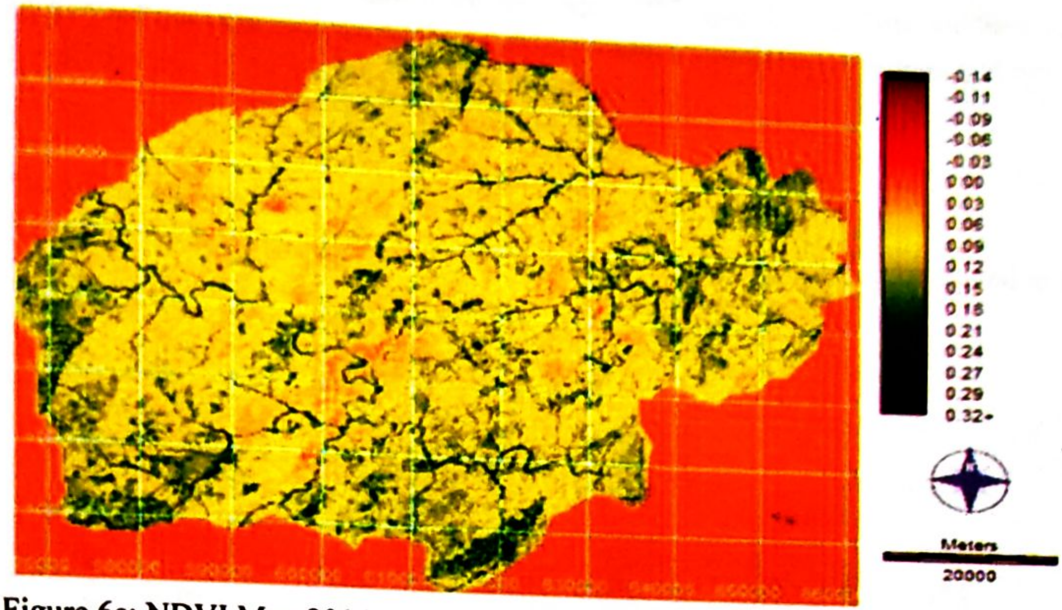


Figure 6c; NDVI Map 2014

The result conforms to trend in the projected figure 7 and variation in land cover figure 8 of the study area. That is the floral cover is moving from dense woodland to shrubs and grass land area.

Projection of Land Cover in the Study Area

The result for the ten years projection made for the study area from 2014 is as presented in figure 7

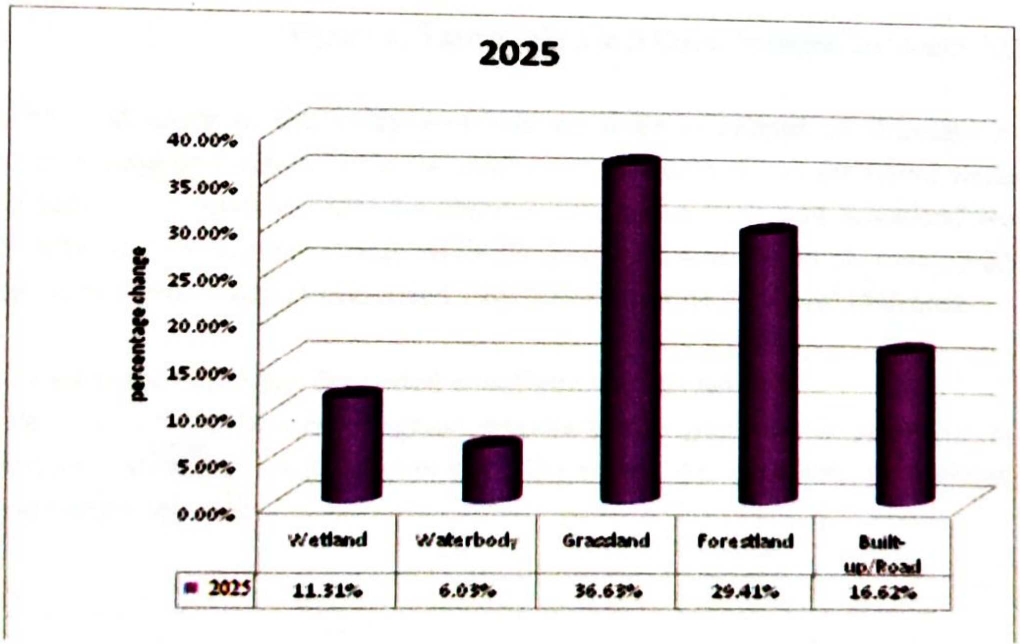


Figure 7: Ten years projected land use class for the study area

This shows that in ten years from the year 2014, that is 2025 the wetland will cover about 11.31% of the total area, water body, 6.03%, while grassland, forestland and built up would take the percentage of 36.63, 29,41 and 16.62 respectively.

Variation in Land Cover between 2014 and 2025

The ten years projection shows variation in the land cover classes as presented in figure 8.

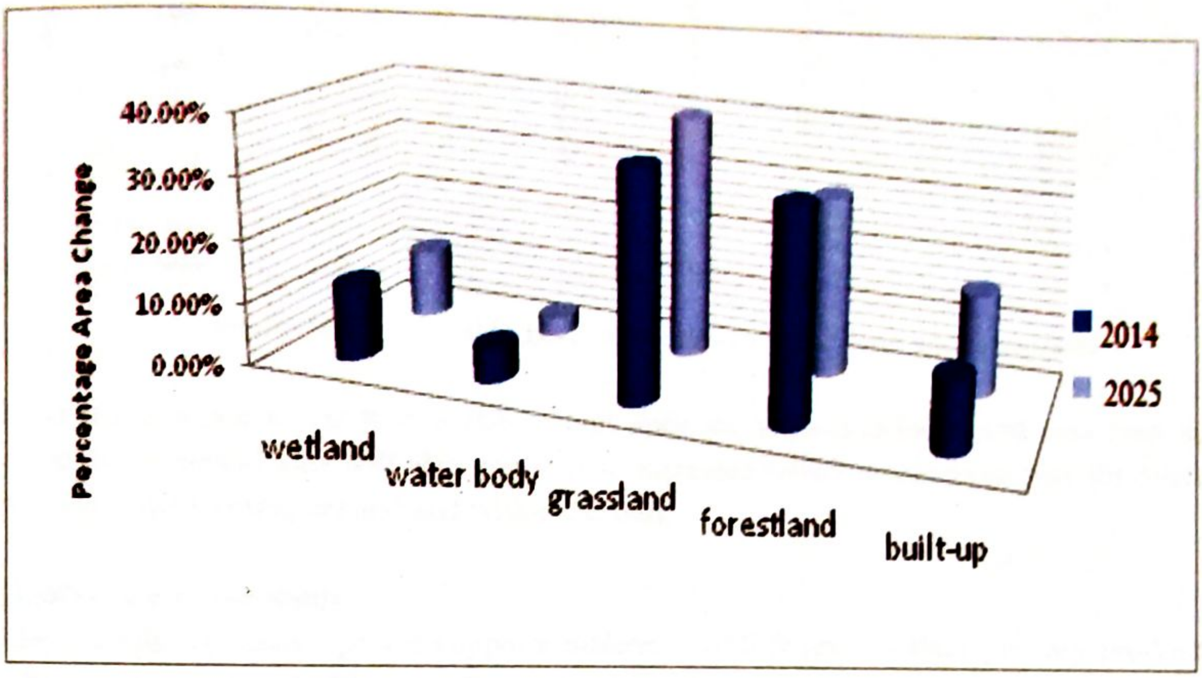
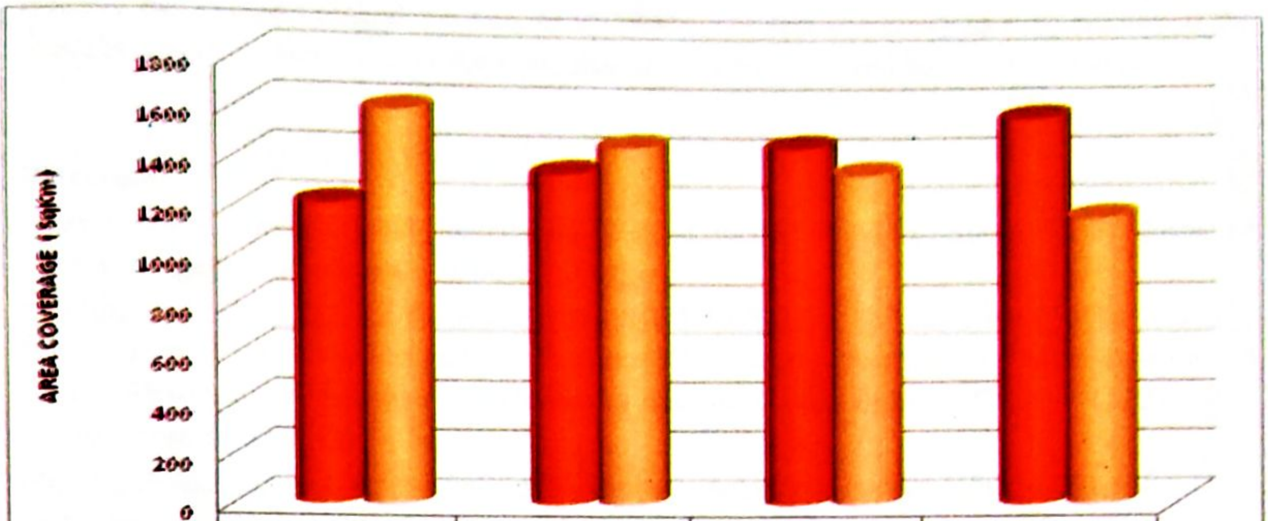


Figure 8: Variation in Land Cover between 2014 and 2025

The land cover in the study area will continue to change or fluctuate if the rate of floral exploitation or degradation in the study area continues. From the figure wetland area is likely to reduce in the years to come by about 0.95%, water body and forestland would also reduce by 2.62% and 5.19% respectively while the grassland area would increase by 2.95. This increase in grassland percentage is associated with the decrease in the forest land area.

Relationship between degraded woodland and Grassland

The relationship between degrade woodland and grassland is presented in the figure 9. The analysis shows a linear relationship that is, as the woodland is declining, the grassland is increasing in area.



	1995	2005	2014	2025
grassland	1217.2	1347.4	1456.2	1573.3
woodland	1601.9	1456.6	1349.4	1167.6

Figure 9: Relationship between degraded woodland and Grassland

From the analysis so far it is pertinent that once the woodland/forestland area continue to be degraded grassland area will also continue to increases which would pave way for other human activities like farming around and within the park.

Implication of the study

The diversity of floral species supports different wildlife and all flora primary production that will ultimately provide fiber, medicine, food and fuel wood and also sequester carbon and thus regulating both local and global climate most especially with the debate regarding carbon sequestration. The issues of afforestation program within the Park can be taken into consideration as a mitigation method in minimizing global warming. Excessive exploitation of the diversity of flora would lead to loss in the different available flora and the primary production and hence generating a source instead of a sink in CO_2 concentration due to human activities. Scientist were of the view that the primary cause of built up in the atmospheric concentration of CO_2 is not just attributed to land use change but largely due to the burning of fossil fuel and other emissions associated with it. The more the number of flora species protected the more the fauna found in the area and the better stable the ecosystem will be within the park.

Conclusion

The bird eye view of the study area by remote sensing technology has proved very useful and most convenient during this research. Assessing the change that have taken place over an expanse of land, that cover 3970km^{2,} could never have been possible within the time and resources available since human error is reduced to the barest minimum. As the spectral response of various land clover types existing in and around the park revealed the activity encroaching and engulfing the park premises which calls for the attention of the management, and the need to sensitize the villagers around the park to avoid and mitigate continuity in such activity at the fringe of the park reserve to save the ecosystem from destruction and human interference.

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