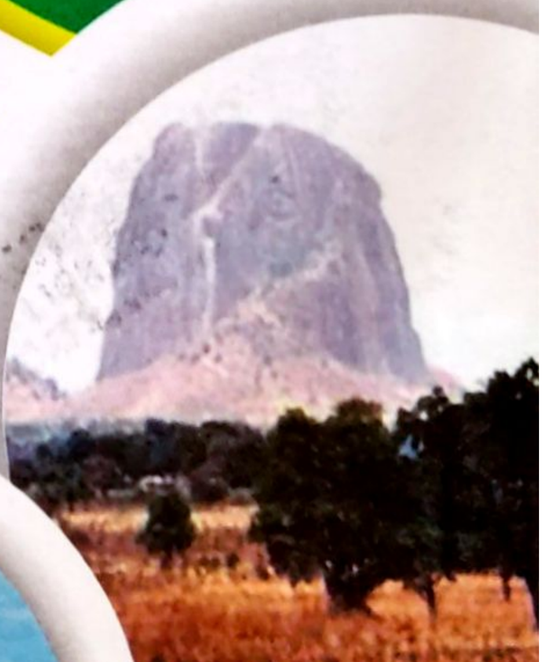
(ISSN: 0794 - 9154)
Volume 4, Number 2, 2013

Nigerian Journal of Tropical Geography

Promoting International Geographical and Environmental Research for Sustainable Development and Solutions

Special Issue "The Role of Environmental Management in Climate Change"



Published by:
Department of Geography
Nasarawa State University
P.M.B 1022, Keffi, Nigeria

ASSESSMENT OF LAND USE LAND COVER CHANGE IN THE BORGU SECTOR OF KAINJI LAKE NATIONAL PARK, NIGERIA: THE ROLE OF LANDSAT 7 ETM IMAGES IN PARK MANAGEMENT

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Abstract

Rapid ecological assessment, land use and land cover change analyses are pre-requisites for improved park management and conservation, so that the maps produced 'tell accurate story' of development in Borgu Park. This paper analyses the contribution of Landsat 7 ETM images in an effort to improve on the current information available on the distribution and status of land cover in Borgu sector of Kainji Lake National Park in the savanna region of Nigeria. The current maps of the study site portray this information by assigning a generalized class of dominantly trees/woodland/shrubs with subdominant grass component to existing land cover. With the aid of intensive fieldwork, a more accurate classification can be achieved. The outcome of the study shows that within the park, gradual changes had taken place from woodland to grassland/shrub to degraded land over the years. Thus, portraying the need for more accurate maps in acceptable scales of 1:10,000 to 1:50,000. In order to safeguard the National Park from management problems caused by illegal human activities such as hunting of wildlife, grazing of livestock, human settlement and farming, the Park authorities need to regularly update land cover maps of the area. This would help set up improved management and conservation plans, which depend on careful inventorying and monitoring of the resources within the Park. Also, for policy makers and managers of the national park, the problem of integrating conflicting demands of land use, ecological conservation and resource protection will be minimized, if information is within easy reach as and when due. This can give way to develop a carbon sink project to attract more funding for managing the park.

Key word: *Analysis, Satellite Imagery, Park Management, Climate Change.*

1 Introduction

The primary function of a national park is the overall protection and sustainable management of a territory where environmental factors of great interest exist. In the northwestern corner of the savanna belt of Nigeria, lies the Borgu sector of the first National Park in the country called Kainji Lake National Park (KLNP) which is made up of two game reserves, Borgu and Zugurma Game Reserves merged together. The game reserves lie at the west of Lake Kainji and eastern bank of River Niger respectively (fig.1), covering an estimated area of approximately 5,341 square kilometers. Borgu Park is the larger of the two, with coverage of about 3971 square kilometers.

In order to safeguard the Park from management problems caused by illegal human activities, a thorough knowledge of the existing reality in the Park must be available to the authorities. First, detailed studies on specific requirements on the land cover categories, various aspects of the functioning of the ecosystems, the ecology of animal species of particular interest, the structure and distribution of vegetation types and socio-economic aspects should be conducted. Secondly, the results must be produced in form of maps, which can be regularly updated. Thirdly, the geoinformation gathered must be integrated in a Geographic Information Systems (GIS) environment for accurate knowledge of aspects that would help set up improved management and conservation plans e.g. the zoning of vulnerable areas. Fourthly, the impact of management and conservation activities adopted should be monitored.

Studies carried out in 1986 had shown that the shrub land of steppe-type was gradually spreading southwards into the dry savanna belt as far as latitude 10 N. While the mixed woodland / grassland, found between 8 - 10N, had shifted with aggressive agrarian adventures of these belts (Adefolalu, 1986). This observation was not adequately reflected on the available (1978 and 1995) land use and vegetation maps of the study area. In both maps, the Park was categorized under the generalized class of dominantly trees/woodland/shrubs with subdominant grass component. For an economically viable area like the Park, detailed, timely, accurate and cost-effective maps are required to provide access to a broad base of physiographic, geormorphic and ecological information in a format that can easily be understood.

Specifically, rapid ecological assessment, land use and land cover change analyses are a necessary pre-requisite for managing and conserving the Park. This is only feasible with the use of current and reliable techniques for collecting environmental data such as remote sensing, GIS and GPS. For policy makers and managers of the national park, the problem of integrating conflicting demands of land use, ecological conservation and resource protection will be minimized, if information is within easy reach as and when due. The main objectives of this paper are to digitally process remotely sensed data sets in order to produce a multitemporal, Maximum Likelihood Classified ETM image and Intensity Hue Saturation (IHS) image and to delineate, map and analyze land cover within the Park. In addition, the nature of possible changes that may have occurred and the present status of land cover would be described.

2 The Study area

Kainji Lake National Park is located in the savanna belt of Nigeria within latitudes 9 40' N, 10 30' N and long 3 30'E and 5 50' Ewith an approximate areal coverage of 5341 square km. For this study, Borgu sector of the Park, being the largest was selected as the study site (see figure 1). The Park was initially set up as an experiment at managing and conserving wildlife resources in Nigeria. But management problems and inadequate information on existing resources have drastically reduced the success of this experiment. The immediate surrounding of the park, a buffer zone of 4km around the Park was also included in the study. The vegetation in this sector is mainly transitional between Sudan and northern guinea savanna woodland, differentiated by hydrological and soil factors. Kainji Lake National Park is well drained, with numerous tributaries from the four major rivers, River Oli to the south, Rivers Wesar and Giwa in the north, Rivers Menai and Timo running through the middle. The soils are mostly waterlogged during the wet season especially in areas close to the main river, River Oli. There are two rural towns within the range of the study site, Babana and Wawa, to the northwest and southeast respectively. Isolated, exposed rocks are found all around the site, with a distinct ridge running across the middle from a North to South direction. The notable rocks are the Kuble and Kali hills to the north and southeast respectively.

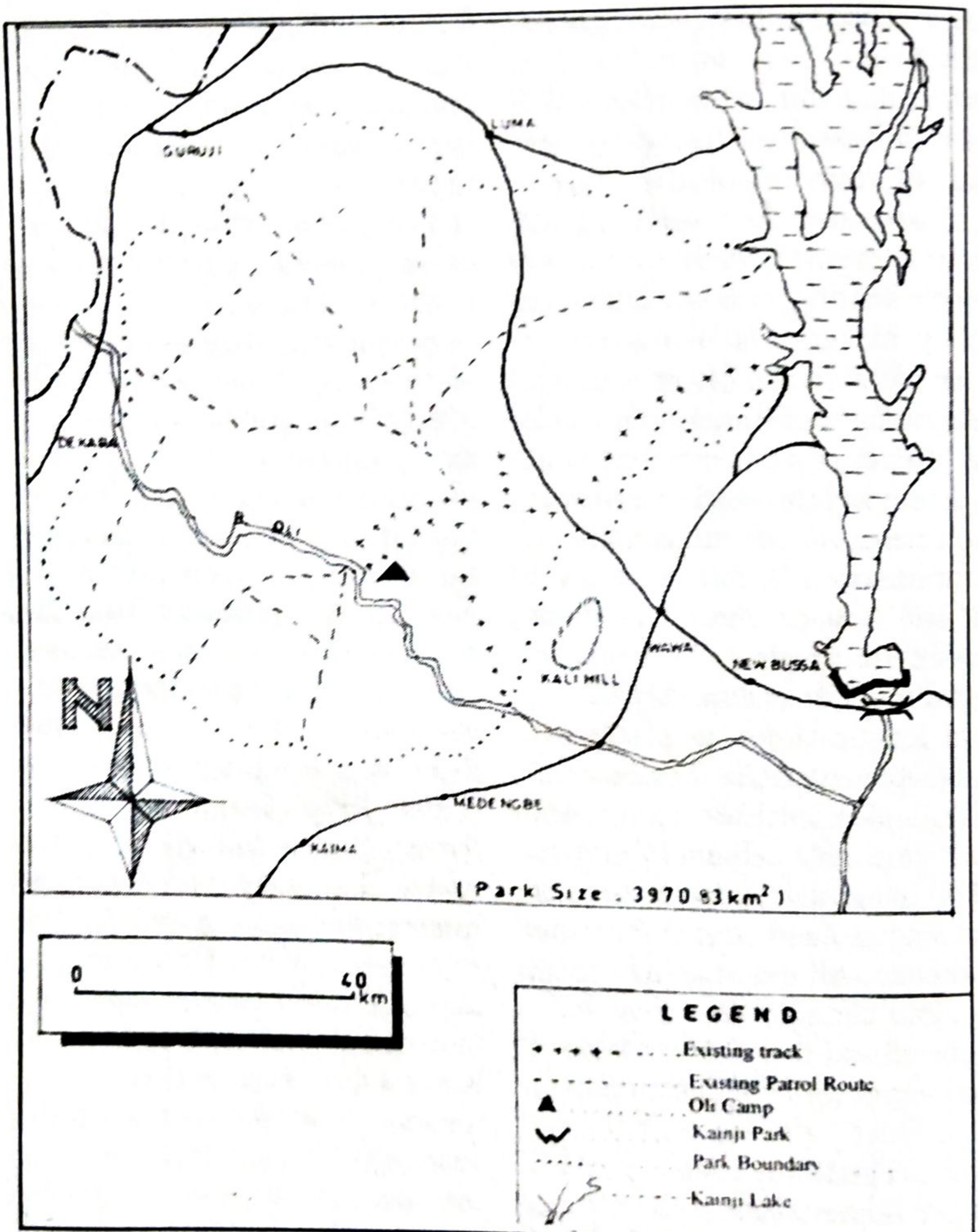


Figure 1 Location of the study area. Source: Park Brochure

3 MATERIALS AND METHODS

A Landsat 7 ETM image for the years 1995, 2000, and 2008 were used. The selection of the scenes was mainly based on availability, and seasonality, reflecting main climatic conditions. All images were of no rain days, so this is not a factor to be considered in the alteration of signal reception by the satellites.

Thematic mapper (ETM+) consists of sensors detecting and recording earth surface radiation in three specific bands: visible and near infrared (VNIR) - bands 1,2,3,4 and 8 (PAN): short wave infrared (SWIR) - bands 5 and 7 and the long wavelength thermal infrared (LWIR) - band 6. These have a spectral range from 0.4 - 1.0, 1.0 - 3.0 and 8.0 - 12.0 micrometers respectively. In this study, Landsat 7 ETM images were exploited for their spectral, drainage and topographic information to study the distribution, nature and status of land cover in the Borgu sector.

In addition to the remotely sensed images, land use and vegetation map produced in 1978 and 1995 were acquired. The field data collection was mainly to familiarize one with the study area, in order to have good background knowledge for interpreting the results of the analysis. The second field data collection was embarked upon after the satellite images had been analyzed. In this case, GARMIN GPS receiver was used to identify ground control points, which were located on the maps. These were used to ensure more accurately georeferenced satellite images that could be studied visually.

This study adopts both digital and visual interpretation combined with intensive field data observation to improve on the previous maps of the study site. Digital image processing of all the data sets acquired was done using ILWIS software

The first step was to perform linear contrast stretch on all the bands, with the exception of band 6, and then the ETM+ bands with 30 meters-pixel size were combined in order to select the most suitable band combination. A False Colour Composite of bands 4, 3 and 2 was chosen as it clearly depicts the vegetation of the study site.

The process of supervised classification, specifically maximum likelihood classification, was applied to the enhanced false colour composite of bands 4, 3 and 2. This technique generates thematic information from multi-spectral remotely sensed images by calculating the probability that a pixel belongs to any one class. Class variance is used and a-priory probability assigned to each class. Then, appropriate training sites were determined using spatially referenced field data. The initial twelve classes selected were subsequently reduced to nine, after studying the resulting confusion matrix. The final classes were closed-canopied woodland savanna, open-canopied woodland savanna, intensive agricultural area (mainly crop production), extensive agricultural area (a mix of crop and pasture), swamp and marsh areas, grassland, water body, bare/degraded land and exposed/bare rock out crops. Summary statistics were calculated to indicate the areal coverage of each land cover category.

Intensity Hue and Saturation (IHS) transform is useful in image enhancement and multi-sensor data merge (Egan, 2004). This was employed for merging of Landsat 7 ETM false color composit (FCC) bands 4, 3, 2 and Panchromatic band with spatial resolution of 30 and 15 meters respectively. In this case, the two data sets were co-registered to a common resolution of 15 meters (Root Mean Square Error of 0.09); the FCC image was converted from RGB (Red, Green and Blue) to HIS coordinates; the PAN image was substituted for the intensity coordinates and converted to RGB space.

4 Results and discussion

Figure 2 shows a Landsat multitemporal image produced using images acquired in 1995, 2000 and 2008. The first observation made from the image was that there were no clearly defined regular fields attributed to agriculture. The green colour in the image showed the dominance of land cover present in 1995, as vegetal growth is vigorous and established. Areas with significant concentration of woodland lie mainly in the western part of the site, with a thin strip running across from north to the southwest. This woodland consists of a mix of Acacia complex, Burkina Africana, Afzelia Africana and Detarium Microcarpum. The thin strip grows on a line of rock outcrops, where vegetation remained undisturbed by bush burning. With the exception of isolated patches of green colour, a distinct patch of unchanged woodland was identified at the southeastern corner of the site. This was the only large size concentration of close-canopied woodland still existing.

Areas in blue indicated land cover dominant in April 2000, a typical dry season period. At this period, all seasonal plants had dried up, leaving only semi permanent to permanent vegetation such as woody shrubs, woodland and riparian forests. This is usually the time bush fires occur, either to manage the dried-up tall grasses (Cylindrical and Andropogon Jayanus) or for game hunting, an illegal activity in the Park. Such exposed lands appeared dark in individual the images. However, it was difficult to distinguish between the burn scars and exposed areas on the image.

While Table 1. shows the interpretation of other notable colors' observed in the image. Generally, the trend of change appeared to be from woodland to grassland, bare and degraded land. Both bare and vegetated rock outcrops were numerous in the image, especially within the thin strip in the middle of the site and north to northeastern sector of the image, but outside the Park. The water bodies (reservoirs) within the park were not visible, possibly because of similar signal response with vegetation. However, those outside the park, within the mainly extensive agricultural area, were clearly visible. Drainage patterns were very visible. This was because the riverbanks were lined with mainly riparian forests.

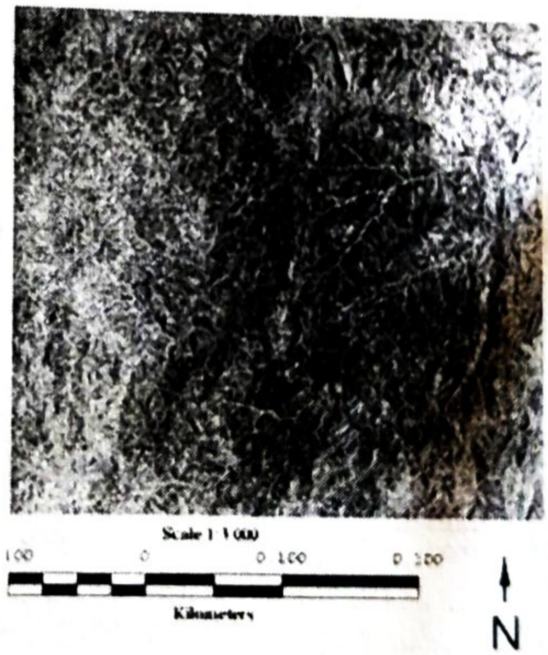


Figure 2 Multitemporal landsat 1995 (Red), 2000 (Green) and 2008 (Blue) image combination. The different bright colours represent the dominant reflectance from land cover types in one or more of the images used.

Figure 3 shows the processed Landsat 7 ETM images. The false colour composite was classified after visual assessment of the image. Based on field data collection, twelve classes were determined and used for image classification. However, these had to be reduced to eight to ensure very minimal confusion between the classes. It was impossible to separate low grass from tall grass and shrubs, bare rock from grassland and to separate the gallery forests from open and close-canopied woodland. Fig 3a shows the maximum likelihood classified image, while figure 4a and 4b gives the estimated areal and percentage coverage of each category compared with the total area of the site. Error resulted from classifying rocks as vegetation (grass or woodland). An accuracy assessment was performed based on stratified-random verification of 20,000 points and 91.08% accuracy was achieved from this process.

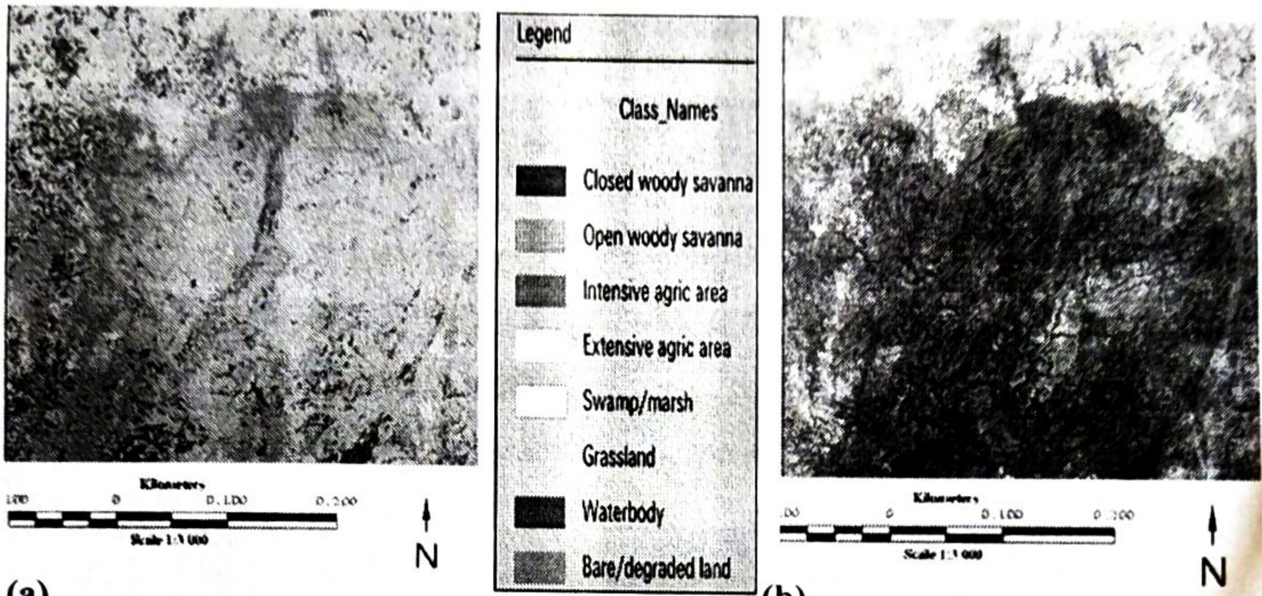
Table 1Landsat multi-temporal interpretation colour key

Colour key	Interpretation
Red	High reflectance from low canopy vegetation (regrowth) in 2008 image.
Green	High reflectance from less dense to dense canopy vegetation (woodland, shrubs).
Blue	High reflectance from less dense canopy vegetation 2000 image (grass/shrubs/thickets with a good degree of surface exposure).
Yellow	High reflectance from low canopy vegetation in 2008 and 1995 images.
Magenta	High reflectance from low canopy vegetation (regrowth) in 2008 and 2000 images.
Orange	Low canopy vegetation
Green/yellow	Dense canopy vegetation: woodland
Orange/yellow	Low canopy vegetation:
White	High reflectance from rural settlement in all images; no change area.
Black	Low reflectance from low canopy (exposed / degraded land) in all images; no change area.

The IHS image produced from a fusion of VNIR bands 4,3,2 and the panchromatic band is shown in figure 3b. Water bodies, vegetation and exposed land surfaces could be easily identified. The different vegetation types could be identified; closed-canopy and open- canopy woody savanna appear as red, with the later having a lighter shade of red.

Agricultural areas could also be

differentiated; orange and light green colours represent intensive and extensive agricultural areas. Water bodies, shrub/grassland and bare/degraded land are depicted in blue, dirty green and tan/white colours. However, swamps/marshy areas were not easy to identify.



(a) (b)

Figure 3 Processed Landsat 7 ETM images: (a) Classified Landsat image (b) Merged Pan and ETM bands.

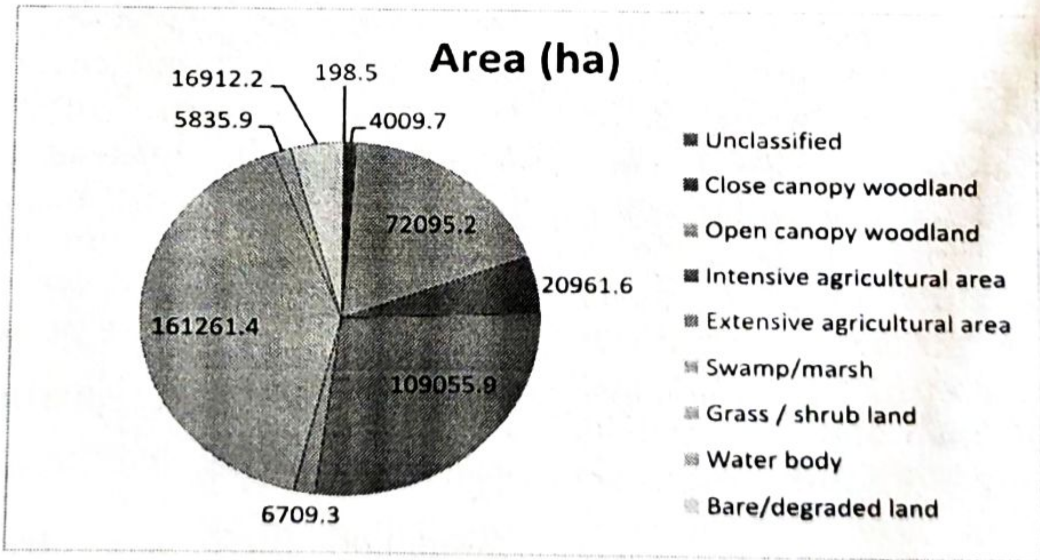


Figure 4a. Areal distributions of different land cover categories using maximum likelihood classification

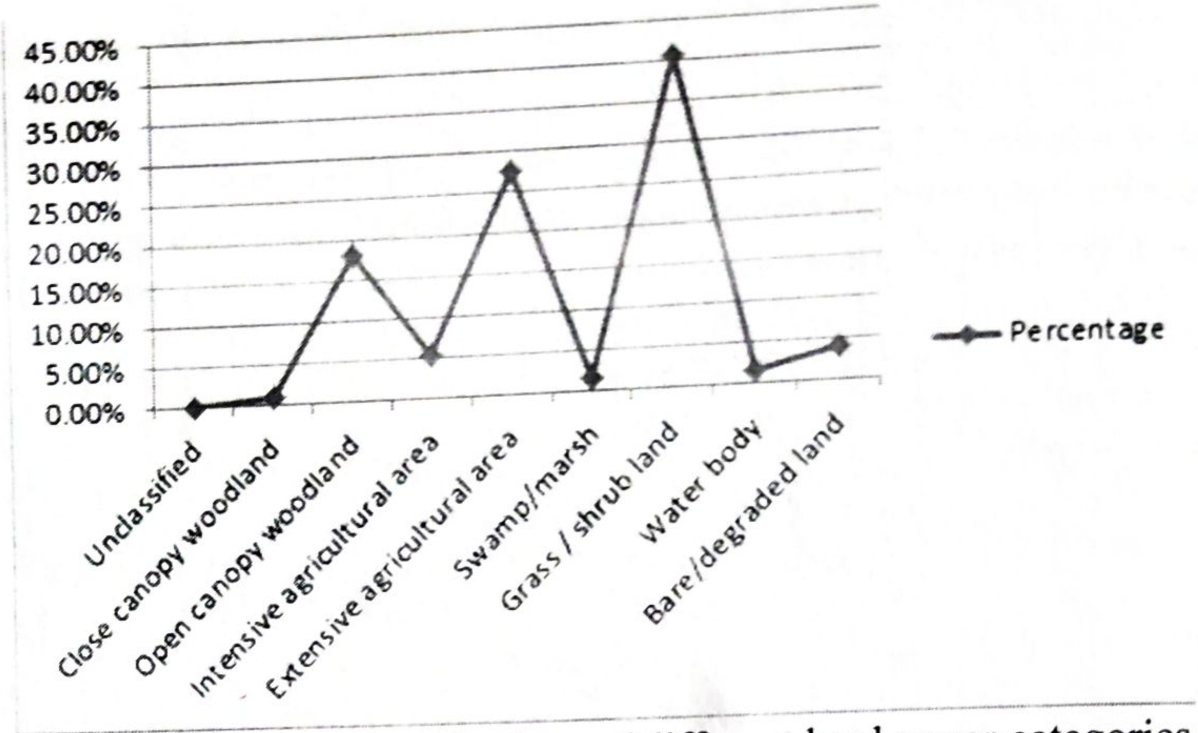


Figure 4b, Percentage distributions of different land cover categories using maximum likelihood classification

The fusion of the different Landsat ETM data resulted in an image with very clearly defined drainage pattern, topographic and spectral information (see figure 5). The reddish colour depicts vegetation; the cyan represents water bodies (note that the reservoirs within the study site are clearly shown in this image), and Babana, a settlement area very close to the Park is shown as white. Figure 6 shows subsets of the upper sector of Borgu Park on the land use and vegetation map and IHS images respectively. Figure 6a depicts the park as dominant trees/woodland/shrubs and subdominant grass component. The only other cover types shown are marsh/swamps and a few of the rivers. Figure 5b shows integration Landsat ETM images resulting in an image with very clearly defined drainage pattern, topography and land cover. The reddish colour depicted vegetation, cyan represents water bodies (note that the reservoirs within the study site are clearly shown in and white shows the only settlement closest to the Park.

Figure 6 shows vector maps of the study site, with the border of Borgu Park outlined. In figure 6a,

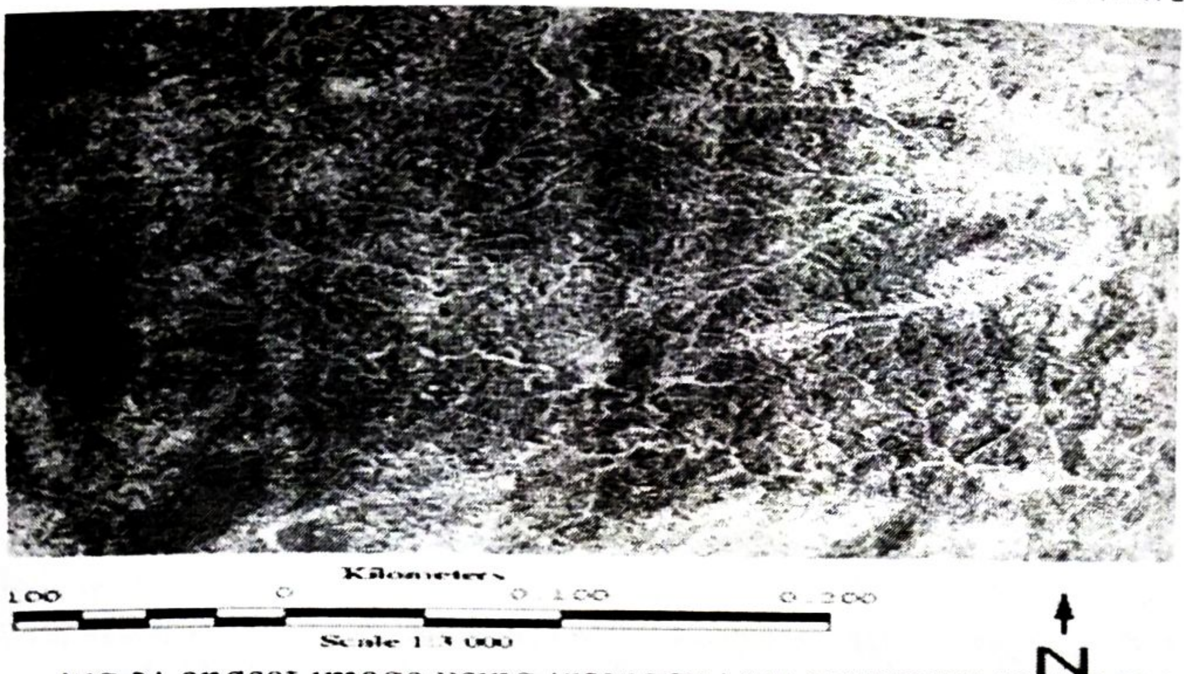


Fig 5Landsat image using Intensity Hue Saturation technique

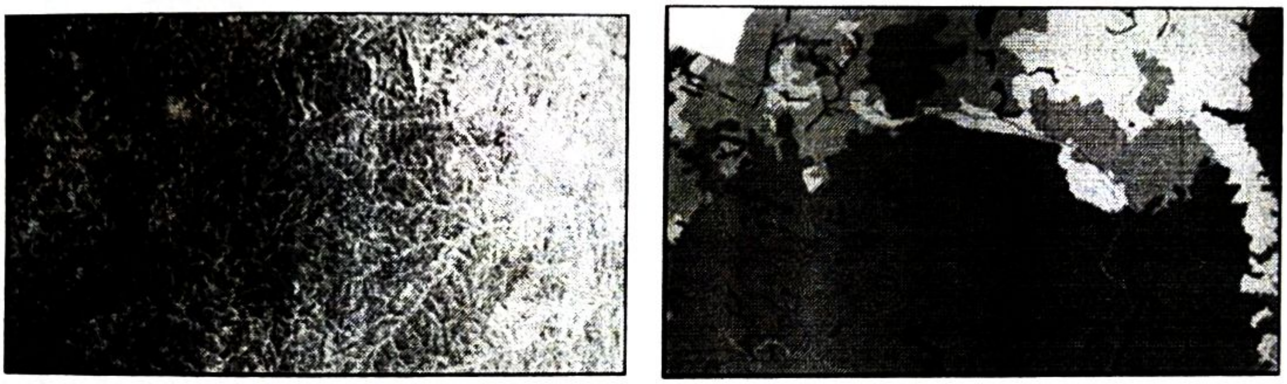


Fig 6 Subsets showing the upper section of Borgu games reserve. (a) Land use and vegetation map of 1995 where green depicts the park as dominant trees/woodland/shrubs and subdominant grass component. (b) IHS image: red indicates woodland vegetation.

The major land cover types distinctively show woodland in red; intensive agricultural areas (concentrated outside the park) in green, yellow and orange (indicating various stages of crop growth); extensive agricultural are in cyan and exposed/degraded land in greenish-blue. The intricate network of drainage channels is shown in figure 5b. An overlay of these two maps in a GIS would be an improvement over previous land cover maps of Borgu Park.

5 Implications for climate change mitigation

The result of this study could be

used as a basis for planning, management and conservation of the resources of Borgu sector of Kainji Lake National Park. The selected study area shows the land cover type within the Park and its immediate environment. From the analyses, uncontrolled human activities can be identified. For example, at the northern border, a mixture of bare land as well as extensive agricultural areas surrounds the Park. While to the southwest, intensive agricultural areas are clearly depicted. The implication is that encroachment from farmers is a serious threat, if non-existent already, since not all parts of the Park are accessible to the Park Rangers. This calls for urgent attention by the Park authorities. Also, a more detailed study involving intensive field data collection in order to identify and locate different vegetation types is necessary. This study could be used as a guide for mapping the position and size of vegetation in the Park, especially species that are edible to the fauna living there. The map produced would serve as essential aid to better control of the grazing by these animals. With this information, under development of the animals and deterioration of the land by excessive pasture would be avoided. Also, sensitive areas can be zoned, so that better attention is paid to their management and protection. The vector maps produced can serve as illustrative tourists' maps showing the different areas of interest. At the same time, these maps would ensure that controlled tourism is practiced.

6 Conclusion

The study has demonstrated that the current available (1995) map of the Borgu sector of Kainji Lake National Park does not accurately depict the present distribution and status of land use and vegetation cover. This is because going by the multi-temporal image interpretation and available literature; it is clear that over the years, gradual changes had taken place from woodland to grassland, bare and finally degraded land. Other products from the analyses reinforce the need for more accurate and refined maps in acceptable scales of 1:10,000 to 1:50,000, which clearly depict the different vegetation types. This is because large areas of grassland had been misinterpreted to be trees/woodland/shrubs. A maximum likelihood classified Landsat FCC image indicated that estimated distribution of the major land cover types were mainly grassland (41%) and woodland (19%).

The pertinent question therefore is: Can the existing 1995 land use and vegetation map be relied upon for future planning and management of the park? Going by the results of this study, it will be risky to do so, since this map is a generalized representation of the reality on ground in the Park. The generation of Digital Elevation Model (DEM), which gives a reliable base for the construction of Geographic Information System (GIS) type of application is ultimately the right approach to sustainable development of the National Park. Further refinement of these results is possible, since more and more sophisticated sensors have either been or about to be launched.

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